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16. ABSTRACT

This bibliography, inclusive from 1967 through 1978, lists all publications authored by researchers employed by the Environmental Research Laboratory, Gulf Breeze, and its field station on St. Johns Island, SC, or by researchers conducting studies under funding or direction of the laboratory.

Publications are grouped in three categories: RESEARCH REPORTS published in the EPA Research Reporting Series; JOURNAL ARTICLES from the scientific literature; and PRESENTATIONS published in proceedings of conferences and symposia. Publications are arranged alphabetically by year under the senior author's name. The bibliography also includes an author index for reprints and an index of key words (as listed in the Thesarus of Engineering and Scientific Terms, 1967, Office of Naval Research and Engineers Joint Council, editors, U.S. Department of Defense, Washington, DC). Entries are numbered consecutively throughout the three sections, and those numbers are used in the indices.

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United States
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Environmental Research
Laboratory
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EPA-600/3-79-036
March 1979

Research and Development

Publications

Gulf Breeze Laboratory

compiled by
Betty P. Jackson and Andree F. Lowry
Environmental Research Laboratory
Gulf Breeze, FL 32561

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Foreword

Protection of our aquatic resources from damage caused by toxic organic and inorganic pollutants requires effective regulatory actions based on sound technical and scientific information. As one of 15 laboratories maintained by the U.S. Environmental Protection Agency (EPA) Office of Research and Development, the Environmental Research Laboratory in Gulf Breeze, Florida (ERL,GB), conducts and manages research and develops methodology to determine exposure-effects of toxic compounds in marine, coastal, and estuarine ecosystems.

From its inception in 1937 as a Fish and Wildlife Service Laboratory under the U.S. Department of the Interior, the laboratory ensured that the research findings of the staff were made available to the scientific community and to the public. Traditionally, laboratory research has been concerned with the effects of pesticides, organics, and chlorine on the environment and human health. More recently, research objectives were expanded to assess the impact of off-shore oil drilling and the environmental acceptability of industrial wastes.

This bibliography lists scientific and technical reports published since 1971 under EPA funding by staff at ERL,GB and its Bears Bluff Field Station at Johns Island, SC, and by scientists whose research was supported by ERL,GB's extramural program. Publications are listed under three headings: RESEARCH REPORTS published in the EPA Research Reporting Series; JOURNAL ARTICLES from scientific literature;PRESENTATIONS published in proceedings of conferences and symposia. Publications are arranged alphabetically by year under the senior author's name. The bibliography also includes an author index for reprints and an index of key words.* A consecutive numbering system precedes each entry and should be cited when requesting copies of available publications.

We prepared this compilation in the hope that products from our research would have the broadest audience possible. We welcome suggestions for enhancing the usefulness of this bibliography in communicating results of our laboratory's environmental research and development.

Thomas W. Duke

Thomas W. Duke
Director
Environmental Research Laboratory
Gulf Breeze, Florida

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*As listed in: Office of Naval Research and Engineers Joint Council. 1967. Thesaurus of Engineering and Scientific Terms. U.S. Department of Defense, Washington, D.C. 696 p.

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Research Reports

Reports listed below were published by the U.S. Environmental Protection Agency (EPA) in its Office of Research and Development (ORD) Research Reporting Series. Research described in these reports analyzes the effects of toxic pollutants on marine and estuarine ecosystems. The purpose of the ORD Program is to provide the Agency with a technical basis for formulating standards to minimize undesirable changes in organisms found in aquatic, terrestrial, and atmospheric environments. These reports are available at EPA's Environmental Research Laboratory, Gulf Breeze, FL 32561, or through the National Technical Information Service, Springfield, VA 22161.

1978

1. Anderson, Robert S. 1978. BENZO[a]PYRENE METABOLISM IN THE AMERICAN OYSTER CRASSOSTREA VIRGINICA. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/3-78-009. 19 p.

    This research program focuses on the role of NADPH-dependent microsomal mono-oxygenase in the metabolism of the widespread environmental carcinogen benzo[a]pyrene (BP) by the oyster Crassostrea virginica. The enzyme system is important in detoxifying various xenobiotics and in activating polycyclic aromatic hydrocarbon oncogens as BP.

    A sensitive radioisotopic system developed to permit quantification of alkalid-soluble and water-soluble BP metabolites produced by oyster mono-oxygenase is described. An NADPH- and O_2-dependent aryl hydrocarbon hydroxylase (AHH) is shown to be located in the digestive glands of bivalves associated with the microsomal subcellular fraction. Some indication that oyster AHH is induced by chronic exposure of the animals to the environmental carcinogens BP and 3-methyl-cholanthrene is reported. Experimental evidence indicates that exposure to polychlorinated biphenyls (PCB) caused AHH induction. The generation of various dihydrodiol, quinone, and hydroxy BP derivates is shown.

2. Bierman, Victor, William Richardson, and Tudor T. Davies. 1978. MATHEMATICAL MODELING STRATEGIES APPLIED TO SAGINAW BAY, LAKE HURON. In: American-Soviet Symposium on Use of Mathematical Models To Optimize Water Quality Management, T.T. Davies and V.R. Lozanskiy, editors. Environmental Research Laboratory,

Gulf Breeze, FL. EPA Ecological Research Series, EPA-600/9-78-024. pp. 397-432.

This research is directed toward water quality problems of international waters of the North American Great Lakes. The prime objective is to develop quantitative tools to supplement intuition and scientific judgment in policy decisions related to water quality. Transport models and algal growth modeling concepts are applied to Saginaw Bay to describe prevailing conditions.

3. Borthwick, Patrick W. 1978. METHODS FOR ACUTE STATIC TOXICITY TESTS WITH MYSID SHRIMP (*MYSIDOPSIS BAHIA*). In: Bioassay Procedures for Ocean Disposal Permit Program, Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/9-78-010. pp. 61-63.

Methods are described for using the bay mysid, *Mysidopsis bahia* in acute toxicity tests of complex wastes. *M. bahia* is recommended as a test species due to its sensitivity, short lifecycle, small size, and adaptability to laboratory conditions. Results of these toxicity tests can be used to estimate the impact of ocean-dumped materials on other saltwater crustaceans.

4. Butler, P.A., and J.I. Lowe. 1978. FLOWING SEAWATER TOXICITY TEST USING OYSTERS (*CRASSOSTREA VIRGINICA*). In: Bioassay Procedures for Ocean Disposal Permit Program, Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/9-78-010. pp. 25-27.

A "special bioassay" for evaluating short-term effects of specific wastes on marine mollusks is described. The procedure is recommended only for use with the commercial Eastern oyster, *Crassostrea virginica*, and requires flowing, unfiltered seawater. The test is used at the Environmental Research Laboratory, Gulf Breeze, to evaluate the effects of insecticides, herbicides, and other toxic organics on oysters.

5. Cross, F.A., W.P. Davis, D.E. Hoss, and D.A. Wolfe. 1978. BIOLOGICAL OBSERVATIONS. In: The Amoco Cadiz Oil Spill: A Preliminary Scientific Report, Wilmot N. Hess, editor. U.S. Department of Commerce National Oceanic and Atmospheric Administration (NOAA)/Environmental Protection Agency (EPA) Special Report, Government Printing Office (GPO), Washington, DC. pp. 197-215.

This report is a compilation of observations and data gathered along the Brittany Coast of France after the *Amoco Cadiz* oil spill. The information does not reflect results of a pre-planned biological study, but rather the qualitative observations by NOAA/EPA biologists from late March to May 1978. The material is described as preliminary; final assessment of the full extent of the impact is expected to require several years.

6. Davies, T.T., and V.R. Lozanskiy, editors. 1978. AMERICAN-SOVIET SYMPOSIUM ON USE OF MATHEMATICAL MODELS TO OPTIMIZE WATER QUALITY MANAGEMENT. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/9-78-024. 453 p.

   The American-Soviet Symposium on Use of Mathematical Models To Optimize Water Quality Management examines methodological questions related to simulation and optimization modeling of processes that determine water quality of river basins. Participants describe the general state of development and application of mathematical models designed to predict and optimize water quality management in the USA and USSR. American and Soviet specialists discuss graphic-economic aspects of pollution control systems; identification of ecosystem models by field data; management decisions for lake systems on a survey of trophic status, limiting nutrients, and nutrient loadings; and a descriptive simulation model for forecasting the condition of a water system. Publication of the proceedings held December 9-16, 1975, in Kharkov and Rostov-on-Don, USSR, is in compliance with the Memorandum from the Fourth Session of the Joint American-Soviet Committee on Cooperation in the Field of Environmental Research.

7. Duke, Thomas W., and Anatoliy I. Simonov, editors. 1978. FIRST AMERICAN-SOVIET SYMPOSIUM ON THE BIOLOGICAL EFFECTS OF POLLUTION ON MARINE ORGANISMS. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/9-78-007. 166 p.

   American and Soviet specialists discuss state-of-the-art for hydrobiological analysis of basic structural components of marine ecosystems and the influence of various pollutants on these components. Participants define problems related to methods for modeling the influence of pollutants on the marine environment, long-term forecasting and determination of permissible loads of pollutants, and the unification and intercalibration of methods for determining production of microorganisms of ocean bacterioplankton and phytoplankton. Results of laboratory research on the influence of pollution on the marine environment are presented. Proceedings held September 20-24, 1976, in Gulf Breeze, Fl, were published in English and Russian in compliance with the Memorandum from the fourth Session of the Joint American-Soviet Committee on Cooperation in the Field of Environmental Research.

8. EPA Ocean Disposal Bioassay Working Group. 1978. BIOASSAY PROCEDURES FOR THE OCEAN DISPOSAL PERMIT PROGRAM. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/9-78-010. 121 p.

   Bioassay procedures are described for toxicity evaluations of waste materials being considered for ocean disposal under EPA's Ocean Disposal Permit Program. Procedures specify use of various organisms representing several trophic levels. Flow-through and static tests are included; methods vary in their utility and complexity. These procedures are not considered "standard methods," but as reference methods or official methods to be used as specified by the EPA Regional Administrator responsible for the permit program. This manual is a revision of EPA-600/9-78-010 published in May 1976.

9. Evans, John E. 1978. FEASIBILITY OF USING BACTERIAL STRAINS (MUTAGENESIS) TO TEST FOR ENVIRONMENTAL CARCINOGENS. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/3-78-042. 118 p.

   This literature review includes published data on the feasibility of using bacteria as screening agents to detect environmental carcinogens. Mutagenicity data are included because growing experimental evidence indicates that most chemical carcinogens are mutagens, and many mutagens may be carcinogens. This report indicates that bacterial mutagenesis can be used to initiate studies designed to screen for potential mutagens and carcinogens in mixed chemical wastes.

10. Hansen, D.J. 1978. LABORATORY CULTURE OF SHEEPSHEAD MINNOWS (_CYPRINODON VARIEGATUS_). In: Bioassay Procedures for Ocean Disposal Permit Program, Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/9-78-010. pp. 107-108.

    Techniques used at the U.S. EPA Environmental Research Laboratory in Gulf Breeze for the culture of sheepshead minnows in aquaria with under-substrate filters or in aquaria supplied with saltwater are described. The procedure accommodates planning for tests to assure availability of required embryos for life-cycle tests, as well as sufficient juveniles for acute static or flow-through tests after acclimation for 2 weeks.

11. Hansen, David J. 1978. IMPACT OF PESTICIDES ON THE MARINE ENVIRONMENT. In: First American-Soviet Symposium on the Biological Effects of Pollution on Marine Organisms, Thomas W. Duke and Anatoliy I. Simonov, editors. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/9-78-007. pp. 126-137.

    Effects of toxicants on the entire life cycle of an oviparous estuarine fish, _Cyprinodon variegatus_, can now be studied; preliminary experiments reveal that this fish typically develops from an embryo to maturity in 10 to 14 weeks, with about 70% survival in the laboratory. Females produce an average of eight eggs per day and fertilization success exceeds 90%. Effects of polychlorinated biphenyl, Aroclor® 1254, and of a pesticide, toxaphene, on developing communities of estuarine animals have been investigated. These studies provide data for predicting pollution-induced shifts in composition of estuarine and animal communities.

12. Hansen, D.J., P.R. Parrish, S.C. Schimmel, and L.R. Goodman. 1978. LIFE-CYCLE TOXICITY TEST USING SHEEPSHEAD MINNOWS (*CYPRINODON VARIEGATUS*). In: Bioassay Procedures for Ocean Disposal Permit Program, Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/9-78-010. pp. 109-117.

    The method described determines effects of continuous exposure of a toxic material on sheepshead minnow embryos and fry: their survival and growth to adulthood, and spawning success. Spawning success is measured by the ability of the fish to spawn naturally, number of eggs spawned, fertilization success, and survival of embryos and fry. Experiment requires 4 to 6 months.

13. Hansen, David J., Steven C. Schimmel, Del Wayne Nimmo, Jack I. Lowe, Patrick R. Parrish, and William H. Peltier. 1978. STATIC METHOD FOR ACUTE TOXICITY TESTS USING FISH AND MACROINVERTEBRATES. In: Bioassay Procedures for Ocean Disposal Permit Program, Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600-9-78-010. pp. 89-96.

    Procedures are described for acute toxicity tests with fish in containers 15 to 20 cm in depth. Tests require saltwater in which healthy animals can survive throughout acclimation and testing without stress as evidenced by unusual behavior or discloration. Appropriate test animals and test materials are specified.

14. Hansen, David J., Steven C. Schimmel, Del Wayne Nimmo, Jack I. Lowe, Patrick R. Parrish, and William H. Peltier. 1978. FLOW-THROUGH METHODS FOR ACUTE TOXICITY TESTS USING FISH AND MACROINVERTEBRATES. In: Bioassay Procedures for Ocean Disposal Permit Program, Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/9-78-010. pp. 97-106.

    Continuous-flow (often referred to as flow-through) bioassays are preferred over static tests in evaluating certain types of wastes to be disposed of at sea, particularly those with high biochemical oxygen demands and those that are unstable or volatile. Many test species of fish and macroinvertebrates have high metabolic rates and are difficult to maintain in jars or tanks of standing seawater. A method is described for a 96-hr, flow-through bioassay on marine fish and macroinvertebrates appropriate for the evaluation of wastes.

15. Jackson, Betty P., editor. 1978. RESEARCH REVIEW. 1977. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/9-78-014, 64 p.

    This report summarizes results of aquatic research conducted by the Environmental Research Laboratory, Gulf Breeze, Florida, Office of Research and Development, U.S. Environmental Protection

Agency from January 1 to December 30, 1977. The research program examines the impact of pesticides and other organic compounds on marine species and communities, and seeks to develop new methodology for determining ecological hazards of chemical substances under simulated natural conditions. Projects are outlined under four categories: research related to toxicological testing; biological processes and effects; development of offshore oil resources; and Kepone in the marine environment. Investigations conducted at the laboratory's Atlantic Coast field station at Bears Bluff, South Carolina, also are reviewed for the year 1977.

16. Jackson, Betty P., editor. 1978. SYMPOSIUM ON PROTECTING THE MARINE ENVIRONMENT: RESEARCH AND REGULATION. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Reporting Series, EPA-600/9-78-006. 38 p.

    This symposium focuses on the essential role of research and regulatory agencies in protecting marine ecosystems. Purpose of the symposium is to commemorate dedication of a new toxicological test facility at the U.S. Environmental Protection Agency's Environmental Research Laboratory in Gulf Breeze, Florida, on October 7, 1977. Participants define the special function of the federal agency scientist, the social responsibility of the scientist, and the need for research in support of environmental regulation. Historical and future objectives of the Gulf Breeze Laboratory are also reviewed.

17. Koch, Robert B. 1978. DETERMINATION OF THE SITE(S) OF ACTION OF SELECTED PESTICIDES BY AN ENZYMATIC-IMMUNOBIOLOGICAL APPROACH. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/3-78-093. 29 p.

    This report describes development of an antibody to an organochlorine pesticide to be used in studies related to its inhibition of the ATPase system. Kelevan, the condensation product of ethyl levulinate and Kepone, was successfully conjugated to bovine serum albumin (BSA), fibrinogen (BF), and gamma globulin (BGG). Rabbits and chickens preimmunized with BSA and then immunized with BSA-Kelevan produced antibodies to both the hapten, Kelevan, and the carrier protein BSA. Antiserum to Kelevan protected ATPase activity against Kepone and its derivatives. The titer of antibody to Kelevan was critical since antiserum with only trace amounts of Kelevan antibody failed to protect the ATPase activity against Kepone inhibition. Antibody was concentrated by Na_2SO_4 fractional precipitation of the antiserum and obtained in pure form by affinity chromatography with BGG-Kel covalently linked to Sepharose 4B. Pure antibody was obtained from untreated blood serum or plasma with no prior pretreatment or fractionation with the BGG-Kel affinity column. Complete protection of mitochondrial mg^{2+}ATPase activity from _in vitro_ inhibition of Kepone was obtained with a 1.2 mg quantity of Na_2SO_4 fractionated antibody and only 120 µg of pure antibody. Reversal of ATPase inhibition was readily obtained by addition of antibody prior to addition of substrate to the reaction mixture.

18. Nimmo, D.R., T.L. Hamaker, and C.A. Sommers. 1978. CULTURING THE MYSID (MYSIDOPSIS BAHIA) IN FLOWING SEAWATER OR A STATIC SYSTEM. In: Bioassay Procedures for Ocean Disposal Permit Program. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/9-78-010. pp. 59-60.

    Methods are described for the culture of the bay mysid, Mysidopsis bahia, for life-cycle toxicity tests in (1) flowing seawater and (2) a re-circulating aquarium. The mysid is considered a practical organism for toxicological and physiological studies during sensitive stages of development.

19. Nimmo, D.R., T.L. Hamaker, and C.A. Sommers. 1978. ENTIRE LIFE-CYCLE TOXICITY TEST USING MYSIDS (MYSIDOPSIS BAHIA) IN FLOWING WATER. In: Bioassay procedures for Ocean Disposal Permit Program, Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/9-78-010. pp. 64-68.

    Procedures of a method are outlined for determining effects of continuous exposure of a pollutant on the survival, reproduction, growth, and behavior of a crustacean, Mysidopsis bahia, throughout a life cycle. The test species can be captured from small shallow ponds fed by saltwater with a small fish net or a 3- to 4-foot push net of small mesh.

20. Parrish, Patrick R., Elizabeth E. Dyar, Joanna M. Enos, and William G. Wilson. 1978. CHRONIC TOXICITY OF CHLORDANE, TRIFLURALIN, AND PENTACHLOROPHENOL TO SHEEPSHEAD MINNOWS (CYPRINODON VARIEGATUS). Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/3-78-010. 53 p.

    Test results are reported of exposures of sheepshead minnows (Cyprinodon variegatus) to three chemicals--chlordane, trifluralin, or pentachlorophenol--in flowing, natural seawater to determine acute and chronic (full life-cycle) effects.

    Mortality of parental fish exposed to mean measured chlordane concentrations $\geq$2.8 µg/l was significantly greater than that of control fish. Hatch of juveniles from embryos of parental fish exposed to $\geq$0.8 µg/l was significantly less than hatch of control juveniles. The estimated maximum acceptable toxicant concentration (MATC) was >0.5<0.8 µg/l and the application factor (AF) limits, 0.04-0.06.

    Exposure to mean measured trifluralin concentrations $\geq$9.6 µg/l significantly decreased growth of parental fish. Fecundity of parental fish exposed to concentrations $\geq$4.8 μg/l was significantly less than that of control fish. Survival and growth of second generation fish were significantly less than the control in concentrations $\geq$9.6 μg/l. The estimated MATC was >1.3<4.8 μg/l and the AF limits, 0.007-0.025.

Mortality of parental sheepshead minnows exposed to mean measured pentachlorophenol concentrations >88 μg/l was significantly greater than mortality of control fish. The estimated MATC was >47<88 μg/l and the AF limits, 0.11-0.20.

21. Tyler-Schroeder, Dana Beth. 1978. CULTURE OF THE GRASS SHRIMP (*PALAEMONETES PUGIO*) IN THE LABORATORY. In: Bioassay Procedures for Ocean Disposal Permit Program, Environmental Research Labortory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/9-78-010. pp. 69-72.

    The grass shrimp, *Palaemonetes pugio*, is useful in assessing toxicity of various materials. It is (1) easily cultured in the laboratory and sensitive to toxicants, and (2) can be exposed to toxicants in flow-through aquaria throughout its life cycle. Culture and holding procedures are described.

22. Tyler-Schroeder, D.B. 1978. STATIC BIOASSAY PROCEDURE USING GRASS SHRIMP (*PALAEMONETES* SP.) LARVAE. In: Bioassay Procedures for Ocean Disposal Permit Program, Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/9-78-010. pp. 73-82.

    Procedures are outlined for static 96-hr bioassays with the grass shrimp larvae, *Palaemonetes* sp. Three species of the genus, *P. pugio*, *vulgaris*, and *intermedius* are easily collected in the field and maintained in the laboratory. Spawning can be induced in the laboratory by manipulating temperature and light. Developing larvae have demonstrated a greater susceptibility to polychlorinated hydrocarbons than observed in adults or juveniles.

23. Tyler-Schroeder, Dana Beth. 1978. ENTIRE LIFE-CYCLE TOXICITY TEST USING GRASS SHRIMP (*PALAEMONETES PUGIO* HOLTHUIS). In: Bioassay Procedures for Ocean Disposal Permit Program, Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/9-78-010. pp. 83-88.

    A method to assess toxicity of a material to all life stages of the grass shrimp in flow-through systems is described. Tests are conducted throughout the life cycle of the shrimp--from juvenile stage of the parental generation, sexual maturation and reproduction, through hatching, larval development and growth of the F_1 generation to juvenile stage. Thereafter, tests may terminate, or exposures can be continued if a determination of effects on F_1 reproduction and F_2 larval development is required.

24. Vernberg, F.J., W. Kitchens, H. McKellar, K. Summers, and R. Bonnell. 1978. THE DYNAMICS OF AN ESTUARY AS A NATURAL ECOSYSTEM, VOL. II. Environmental

Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/3-78-092. 29 p.

This report describes two separate but interrelated substudies: an update of the macroecosystem model of the North Inlet Estuary near Georgetown, SC, and a continuing study of experimental salt-marsh microecosystems. The model is under development to help understand the interactions of various parts of a natural ecosystem. The principal objective of the study is to develop and test replicate experimental salt-marsh units at the microecosystem level as diagnostic tools for assessing long- and short-term pollution effects on the *Spartina alterniflora* salt-marsh community.

Because of the complexity, this study was conceived as a five-year work. Two years of study (March 1, 1976, to February 28, 1978) are reported. A summary of the first phase of this research is contained in the Ecological Research Series (EPA-600/3-77-016, January 1977).

25. Walker, William W. 1978. INSECTICIDE PERSISTENCE IN NATURAL SEAWATER AS AFFECTED BY SALINITY, TEMPERATURE, AND STERILITY. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/3-78-044. 25 p.

Effects of temperature, salinity, and sterility on the degradation of malathion, parathion, methyl parathion, diazinon, and methoxychlor in fresh and estuarine water under controlled conditions are reported. Surface water samples of 1, 10, 20, and 28 $^{0}/_{00}$ salinity were amended with these insecticides and incubated in the dark at 30°, 20°, and 10°C under sterile and nonsterile conditions. Insecticide abatement was followed by electron-capture gas-liquid chromatographic techniques.

No significant differences between sterile and nonsterile treatments were observed for any of the insecticide studies; the effect of increasing temperature was highly significant with regard to increased degradation of malathion, parathion, methyl parathion, and diazinon. Methoxychlor reflected the recalcitrance characteristic of the chlorinated hydrocarbon insecticides throughout 84 days of incubation and was not significantly affected by salinity, temperature, or sterility. Salinity effects were varied among the four organophosphates: highly significant for malathion and diazinon, significant for methyl parathion, and not significant for parathion.

26. Wilkes, Frank G. 1978. MICROCOSMS AS BIOLOGICAL INDICATORS OF POLLUTION. In: First American-Soviet Symposium on the Biological Effects of Pollution on Marine Organisms, Thomas W. Duke and Anatoliy I. Simonov, editors. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/9-78-007. pp. 155-56.

Research conducted and supported by the Environmental Research Laboratory, Gulf Breeze, to develop microcosms as a method for investigating pollutant fate and effects in the environment is described. Ecosystem compartments under investigation include direct accumulation from water and food by organisms at all trophic levels, bioaccumulation through food chains, direct effects of pollutants on organisms, i.e., mortality, reproduction and behavior, and indirect effects of sublethal levels of pollutants, such as changes in predator-prey relationships. Microbial processes at both air-water and sediment-water interfaces are investigated as well as physical and chemical transformations.

1977

27. Ahearn, Donald G., S.A. Crow, and W.L. Cook. 1977. MICROBIAL INTERACTIONS WITH PESTICIDES IN ESTUARINE SURFACE SLICKS. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/3-77-050. 22 p.

This report describes estuarine surface films from Escambia Bay, Florida, and adjacent waters sampled by the membrane adsorption technique to enumerate microbial populations. Samples of the upper 10 μm of estuarine surface films yielded microbial populations up to 10^8 ml^{-1} or 10^5 cm^{-2}. These populations were 10 to 100 times greater than those in underlying waters of 10 cm. Predominant bacteria in surface films as isolated on Marine Agar were motile, nonpigmented, gram-negative rods. Colony-forming units of yeasts and molds on Mycological Agar prepared with 50% seawater were found in concentrations to 10^4 ml^{-1} or 28 cm^{-2}. The predominant surface film isolates from Marine agar were proeolytic and amylolytic but exhibited only weak to negligible hydrocarbonoclastic and lipolytic activities. A greater proportion of the surface-film bacteria, as compared to those at 10 cm depth, were capable of growth on freshwater media.

With selective isolation media, amylolytic, and lipolytic bacteria appeared to comprise a more significant proportion of the total population. Twenty-one representative bacteria, yeasts, and filamentous fungi from initial sampling of surface microlayers were tested for the effects of selected pesticides on utilization of various substrates. One bacterium was sensitive to PCB formulations. In subsequent studies with 53 isolates representative of more diverse physiological groups, o-chloro-napthalene, PCB 1016, and pentachlorophenol were inhibitory to a large portion of the isolates and heptachlor, biphenyl, pyrene, and PCB 1016 significantly reduced hexadecane utilization.

28. Caldwell, Richard S. 1977. BIOLOGICAL EFFECTS OF PESTICIDES ON THE DUNGENESS CRAB. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/3-77-131. 125 p.

The toxicity of nine pesticides to various life history stages of the Dungeness crab, Cancer magister, is examined to establish the most sensitive life stage of the crab, and the highest concentration of each pesticide having no discernible effect on the most sensitive stage during prolonged exposures. The compounds tested were the insecticides carbofuran, chlordane, malathion, and methoxychlor; the herbicides 2,4-D, DEF, propanil, and trifluralin; and the fungicide captan.

29. Colwell, Rita R., and Gary S. Sayler. 1977. EFFECTS AND INTERACTIONS OF POLYCHLORINATED BIPHENYL (PCB) WITH ESTUARINE MICROORGANISMS AND SHELLFISH. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/3-77-070. 45 p.

This report describes the role of estuarine bacteria in the mobilization, transport, and removal of polychlorinated biphenyls (PCB's) in estuarine environments. A secondary impact of PCB contamination of estuarine systems is reported: the PCB-stress-induced accumulation and depuration of enteric bacteria by shellfish, i.e., the Chesapeake Bay oyster, Crassostrea virginica.

In this report, bacteria uninhibited by PCB, but capable of growth in the presence of PCB, are defined as PCB-resistant. PCB-resistant bacteria are shown to be distributed ubiquitously throughout the estuarine and marine environments sampled. Residence time of PCB in estuarine and marine environments is considered to be sufficiently long to induce stress upon estuarine animals.

30. Crane, Allan M., and Anne E. Freeman. 1977. WATER-SOFTENING AND CONDITIONING EQUIPMENT: A POTENTIAL SOURCE OF WATER CONTAMINATION. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/3-77-107. 8 p.

Chloroform, trichloroethene, and tetrachloroethene as well as two unidentified compounds were adsorbed from contaminated ground water onto anion-cation exchange resins during their regeneration and cleaning at the distributing plant. Contaminants leached into water passed through the resins after distribution resulted in contamination of deionized water supplies of users. Concentrations of chloroform and trichloroethene, greater in filtered water than concentrations observed in contaminated ground water, indicate the ability of resins to concentrate these compounds. Regeneration and cleaning of contaminated resins by commercial procedures with clean water is ineffective. Contaminated resins, which leached 60 μg/l of chloroform into water, leached 47 μg/l after being returned to the distributor and regenerated with clean water. Need for an increased awareness of the limits of ion resins and stricter water quality control of distributors are indicated.

31. Davis, William P., Douglas P. Middaugh, James H. Carpenter, George R. Helz, and Morris H. Roberts, Jr. 1977. THE CHEMISTRY AND ECOLOGICAL EFFECTS OF CHLORINATION OF SEAWATER: A SUMMARY OF EPA RESEARCH PROJECTS. In: Program Review Proceedings of Environmental Effects of Energy Related Activities on Marine/Estuarine Ecosystems. EPA Office of Energy, Minerals and Industry and Office of Research and Development, Washington, DC. U.S. EPA Ecological Research Series, EPA-600/7-77-111. pp. 175-185.

    Since 1975, The Gulf Breeze Environmental Research Laboratory's Bears Bluff Field Station near Charleston, SC, has coordinated a study of the marine aspects of chlorination. This research, and grants supported by EPA's Office of Energy, Minerals and Industry (OEMI) are designed to establish a scientific basis for decisions guiding future energy production and usage, as well as environmental protection measures. This report summarizes results of this research. Needs of further investigations are discussed.

32. Engler, Robert M., and Frank G. Wilkes, editors. 1977. ECOLOGICAL EVALUATION OF PROPOSED DISCHARGE OF DREDGED MATERIAL INTO OCEAN WATERS: IMPLEMENTATION MANUAL FOR SECTION 103 OF PUBLIC LAW 92:532 (MARINE PROTECTION, RESEARCH, AND SANCTUARIES ACT of 1972). U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 19 p.

    Procedures are presented for evaluating potential environmental impacts of the discharge of dredged materials in ocean waters. This evaluation is required in applications for permits for ocean disposal of dredged materials. The manual contains guidelines developed by the EPA/Corps of Engineers Technical Committee on Criteria for Dredged and Fill Material.

33. Hansen, David J., Del Wayne R. Nimmo, Steven C. Schimmel, Gerald E. Walsh, and Alfred J. Wilson, Jr. 1977. EFFECTS OF KEPONE ON ESTUARINE ORGANISMS. In: Recent Advances in Fish Toxicology, a Symposium. U.S. Environmental Protection Agency, Cincinnati, OH, EPA-600/3-77-085. pp. 20-30.

    Results of laboratory toxicity tests to determine the effects and accumulations of Kepone in estuarine algae, mollusks, crustaceans, and fishes are reported. In these tests, nominal Kepone concentrations calculated to decrease algal growth by 50% in static, 7-day bioassays are: 350 μg/l, _Chlorococcum_ sp.; 580 μg/l, _Dunaliella tertiolecta_; 600 μg/l, _Nitzschia_ sp.; and 600 μg/l, _Thalassiosira pseudonana_. Measured Kepone concentrations calculated to cause 50% mortality in flowing-seawater toxicity tests lasting 96 hr are: 10 μg/l for the mysid shrimp (_Mysidopsis bahia_); 120 μg/l for the grass shrimp

(Palaemonetes pugio); >210 µg/l for the blue crab (Callinectes sapidus); 70 µg/l for the sheepshead minnow (Cyprinodon variegatus); and 6.6 µg/l for the spot (Leiostomus xanthurus). Bioconcentration factors (concentration in whole animals divided by concentration measured in water) in these tests are shown to be greatest for fishes (950 to 1,900) and least for grass shrimp (420 to 930).

34. Parrish, Patrick R., Elizabeth E. Dyar, Mark A. Lindberg, Chiara M. Shanika, and Joanna M. Enos. 1977. CHRONIC TOXICITY OF METHOXYCHLOR, MALATHION, AND CARBOFURAN TO SHEEPSHEAD MINNOWS (CYPRINODON VARIEGATUS). Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/3-77-059. 36 p.

    Sheepshead minnows (Cyprinodon variegatus) were exposed to each of three pesticides--methoxychlor, malathion, and carbofuran--in flowing seawater to determine the acute and chronic (partial life-cycle) effects.

    Mortality of adult fish exposed to concentrations of methoxychlor ≥23 µg/l and hatching success of fry from eggs spawned by fish exposed to 23 µg/l were significantly different from the control. The maximum acceptable toxicant concentration (MATC) was estimated to be >12<23 µg/l; application factor (AF) limits were 0.24-0.47.

    Mortality of adult fish exposed to concentrations of malathion ≥18 µg/l and mortality of fry hatched from eggs spawned by fish exposed to 9 and 18 µg/l were significantly different from the control. The MATC was estimated to >4<9 µg/l; AF limits were 0.08-0.18.

    Mortality of adult fish exposed to concentrations of carbofuran ≥49 µg/l, hatching success of fry from eggs spawned by fish exposed to 49 µg/l, and mortality of fry hatched from eggs spawned by fish exposed to 23 and 49 µg/l were significantly different from the control. The MATC was estimated to >15<23 µg/l; AF limits were 0.04-0.06.

35. Sikka, Harish C., and Gary L. Butler. 1977. EFFECTS OF SELECTED WASTEWATER CHLORINATION PRODUCTS AND CAPTAN ON MARINE ALGAE. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/3-77-029. 38 p.

    Effects of stable chloro-organic compounds formed during chlorination of sewage effluents on growth of marine unicellular algae are reported. Captan suppressed growth of Dunaliella tertiolecta and Porphyridium cruentum at 5 parts per million (ppm). Growth of Skeletonema costatum was inhibited by 0.25 ppm captan; 3-Chlorobenzoic acid inhibited growth of S. costatum at 10 ppm but had no effect on D. tertiolecta or P. cruentum. There was no effect of 1-10 ppm 5-chlorouracil on S. costatum, but growth of

D. tertiolecta was stimulated initially. Growth of S. costatum was inhibited by 1 ppm 4-chlororesorcinol, and 10 ppm inhibited growth of P. cruentum. At 1 ppm, 3-chlorophenol stimulated growth of all three species, but growth of S. costatum was inhibited by 2.5 ppm. A combination of 3-chlorophenol and 4-chlororesorcinol interacted synergistically to reduce growth of S. costatum.

It is concluded that chloro-organic compounds formed during chlorination of sewage effluent are not an immediate threat to marine unicellular algae.

36. Summers, Max D. 1977. CHARACTERIZATION OF SHRIMP BACULOVIRUS. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/3-77-130. 36 p.

The research described involves the partial characterization of a baculovirus of the pink shrimp, Penaeus duorarum. The significance of the study relates to the fact that the shrimp baculovirus is morphologically similar to insect baculoviruses that were considered unique to insect arthropods prior to the discovery of shrimp nuclear polyhedrosis baculovirus (NPV). Further, insect baculoviruses are being developed and applied as microbial pesticides for the control of certain agricultural insect pests. Baculovirus diseases in pests of agricultural or medical importance are considered a desirable relationship, but a baculovirus infection in shrimp is undesirable.

The biochemical, structural, and, when appropriate, biological properties of the shrimp virus are compared to known and characterized properties of insect baculoviruses, both granulosis and NPV's. Evidence for any structural relatedness of the shrimp NPV to insect NPV's is confirmed in cross-reactions of purified shrimp NPV polyhedrin and infected shrimp tissues.

37. Vernberg, F.J., R. Bonnell, B. Coull, R. Dame, Jr., P. DeCoursey, W. Kitchens, Jr., B. Kjerfve, H. Stevenson, W. Vernberg, and R. Zingmark. 1977. THE DYNAMICS OF AN ESTUARY AS A NATURAL ECOSYSTEM. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/3-77-016. 86 p.

This report summarizes the first two years of a proposed five-year study of the dynamics of a relatively undisturbed estuary-marshland ecosystem, the North Inlet Estuary near Georgetown, SC. Two substudies are described: a macroecosystem substudy and a microecosystem substudy. Objectives of the macroecosystem study include: (1) to establish baseline data on an undisturbed estuary as a basis for comparative studies on effects of various pollutant stress on other estuarine environments; (2) to develop models of an estuarine ecosystem to predict probable effects of environmental perturbation. Principal objective of the microecosystem study include development and testing of replicate experimental saltmarsh units at the microecosystem level as diagnostic tools to assess long- and short-term pollution effects on the Spartina alterniflora salt-marsh community.

A conceptual model of energy flow for the entire marsh estuarine ecosystem developed as three sub-models is described. Completion of a simulation of the water column submodel and a linear systems model of an inter-tidal oyster community is reported.

38. Wilkes, Frank G., and Robert M. Engler, editors. 1977. FIRST ANNUAL REPORT: ENVIRONMENTAL PROTECTION AGENCY/CORPS OF ENGINEERS TECHNICAL COMMITTEE ON CRITERIA FOR DREDGED AND FILL MATERIAL. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. 41 p.

The EPA/Corps of Engineers Technical Committee on Criteria for Dredged and Fill Material coordinates and disseminates results of research related to criteria and guidelines for regulating the discharge of dredged and fill material as mandated by Public Laws 92-500 and 92-532. The committee's first annual report outlines the purpose of its six subcommittees and its research priorities. Ongoing research programs of participating agencies are listed.

1976

39. Bookhout, Cazlyn G., and John D. Costlow, Jr. 1976. EFFECTS OF MIREX, METHOXYCHLOR, AND MALATHION ON DEVELOPMENT OF CRABS. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/3-76-007. 85 p.

Results of laboratory experiments to determine the effects of mirex, methoxychlor, and malathion on the first larval development of Callinectes sapidus from hatching until the first crab stage are described. Comparison is made with similar investigations to ascertain effects of methoxychlor and malathion on larval development of Rhithropanopeus harrisii.

The effect of a range of concentrations of each insecticide on survival of larvae of C. sapidus and R. harrisii is shown as well as sublethal and lethal concentrations. Zoeal and total development to the first crab stage of R. harrisii and C. sapidus are found to be prolonged in relation to increased concentrations of methoxychlor and malathion. Other sublethal effects of methoxychlor and malathion observed include abnormal development of the pleopods of male R. harrisii and male C. sapidus early crab stages, and autotomy of the legs of R. harrisii megalopa and early crab stages. The developmental stages in which larvae are particularly sensitive vary in the two species and with the three insecticides. Mirex residues of C. sapidus larvae reared in different concentrations of mirex, and methoxychlor residues of R. harrisii and C. sapidus larvae reared in concentrations of methoxychlor are described.

40. Bourquin, Al W., and D.G. Ahearn. 1976. MICROBIOLOGY AND CHEMISTRY OF ESTUARINE SURFACE MICROLAYERS. In: Proceedings of the International Symposium on Marine Pollution Research, January 27-29, 1976, Environmental Research Laboratory, Gulf Breeze, FL, Samuel P. Meyers, editor. U.S. EPA Ecological Research Series, EPA-600/9-76-032. pp. 89-96.

Organic microlayers occur at the air-water interface at most bodies of water. This paper reviews microbiological analyses of surface microlayer that show inshore films yielding microbial populations up to $10^8/ml^{-1}$ or $10^5/cm^{-2}$. Concentrated surface slick samples separated on a silica gel column, and various fractions, indicate the presence of electrophilic compounds coupled with the higher abundance of hydrocarbons. It is hoped that confirmed identification of these compounds will yield information on the possible fate of chlorinated hydrocarbons in surface films.

41. Butler, Philip A. and Jack I. Lowe. 1976. FLOWING SEAWATER TOXICITY TEST USING OYSTERS (CRASSOSTREA VIRGINICA). In: Bioassay Procedures for the Ocean Disposal Permit Program, Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/9-76-010. pp. 81-83.

A "specific bioassay" for evaluating short-term effects of specific wastes on marine mollusks is described. The procedure is recommended only for use with the commercial Eastern oyster, Crassostrea virginica, and requires flowing, unfiltered seawater. The test is used at the Environmental Research Laboratory, Gulf Breeze, to evaluate the effects of insecticides, herbicides, and other toxic organics on oysters.

42. Coppage, David L. 1976. FISH BRAIN ACETYLCHOLINESTERASE INHIBITION ASSAY. In: Bioassay Procedures for the Ocean Disposal Permit Program, Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/9-76-010. pp. 91-95.

Procedure is described for determining the effect of materials to be dumped in the ocean on acetylcholinesterase (AChE) in fish brains. This test pertains to nerve poisons that disrupt nerve impulse transmission by inhibiting AChE, the enzyme that modulates levels of the neurotransmitter acetylcholine. This procedure is not necessary for materials containing no AChE-inhibiting poisons.

43. Coppage, David L. 1976. BIOASSAYS AS INDICATORS OF POLLUTION EFFECTS. In: Proceedings of the International Symposium on Marine Pollution Research, January 27-29, 1976, Environmental Research Laboratory, Gulf Breeze, FL,

Samuel P. Meyers, editor. U.S. EPA Ecological Research Series, EPA-600/9-76-032. pp. 131-139.

> Marine bioassays are used to determine a pollutant's (a) potential to harm organisms, (b) persistence and degradability, (c) rate of accumulation and loss in organisms consumed by other organisms, (d) mode of action on organisms. This paper describes three interrelated bioassays (macroscopic, microscopic, and metabolic) used at the U.S. EPA Environmental Research Laboratory, Gulf Breeze. Results of bioassays are cited as examples of their variety and application.

44. EPA Ocean Disposal Bioassay Working Group. 1976. BIOASSAY PROCEDURES FOR THE OCEAN DISPOSAL PERMIT PROGRAM. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/9-76-010. 121 p.

> This manual contains bioassay procedures developed for toxicity evaluations of waste materials under consideration for an Ocean Disposal Permit. Nine tests are described; three are considered "special" and are not recommended for routine use. Methods vary in utility and complexity and are to be used in accordance with the judgment of the EPA Regional Administrator responsible for the management of EPA's Ocean Disposal Permit Program.

45. Hansen, David J. 1976. TECHNIQUES TO ASSESS THE EFFECTS OF TOXIC ORGANICS ON MARINE ORGANISMS. In: Water Quality Research of the U.S. Environmental Protection Agency, Cincinnati, OH. U.S. EPA Ecological Research Series, EPA-600/3-76-079. pp. 63-76.

> This report describes bioassay techniques that can be used to determine long-term effects of one or more toxicants on the survival, growth, and fertility of individual species of mollusks, arthropods, or fish and on communities of estuarine organisms. These studies provide data for predicting pollution-induced shifts in composition of estuarine animal communities.

46. Hansen, David J., and Steven C. Schimmel. 1976. CHRONIC BIOASSAY USING SHEEPSHEAD MINNOWS (CYPRINODON VARIEGATUS). In: Bioassay Procedures for the Ocean Disposal Permit Program, Environmental Research Laboratory, Gulf Breeze, Fl. U.S. EPA Ecological Research Series, EPA-600/9-76-010. pp. 69-80.

> A procedure is described for determining the effect of a material on survival of sheepshead minnow embryos and fry, their growth to adulthood, and spawning success. The latter is measured by the ability of pairs of fish to spawn naturally, fecundity, fertilization success, and survival of embryos and fry. This test has several limitations and is not considered valid for toxicity assessment of all materials.

47. Hansen, David J., Steven C. Schimmel, Del Wayne Nimmo, Jack I. Lowe, Patrick R. Parrish, and William H. Peltier. 1976. CONTINUOUS-FLOW METHOD FOR ACUTE

TOXICITY TESTS USING FISH AND MACROINVERTEBRATES. In: Bioassay Procedures for the Ocean Disposal Permit Program, Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/9-76-010. pp. 69-80.

> Continuous-flow (often referred to as flow-through) bioassays are preferred over static tests in evaluating certain types of wastes to be disposed of at sea, particularly those with high biochemical oxygen demands and those that are unstable or volatile. Many test species of fish and macroinvertebrates have high metabolism rates and are difficult to maintain in jars or tanks of standing seawater. A method is described for a 96-hr, flow-through bioassay on marine fish and macroinvertebrates appropriate for the evaluation of wastes.

48. Lincer, Jeffrey L., Marita E. Haynes, and Marian L. Klein. 1976. THE ECOLOGICAL IMPACT OF SYNTHETIC ORGANIC COMPOUNDS ON ESTUARINE ECOSYSTEMS. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/3-76-075. 353 p.

> This review and indexed bibliography concerns the presence and effects of pesticides (i.e., insecticides, herbicides, fungicides, etc.) and industrial toxicants in the estuarine ecosystem. Industrial toxicants primarily include polychlorinated biphenyls, although phthalate esters, polychlorinated terphenyls, chlorinated dibenzo-dioxins, and dibenzofurans also are discussed. The review covers literature of the last decade, emphasizing the most recent 5 years. However, the 700-plus references in the bibliography span a wider range. A permuted keyword retrieval system (SPINDEX) allows practical use of the bibliography.

49. Meyers, Samuel P., editor. 1976. PROCEEDINGS OF THE INTERNATIONAL SYMPOSIUM ON MARINE POLLUTION RESEARCH. January 27-29, 1976, Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/9-76-032. 171 p.

> The International Symposium on Marine Pollution Research focuses on the continual and increasing pollution of the marine environment, particularly the adverse effects of marine pollution on the production of protein from the sea. Participants examine environmental problems of global and national interest, including: effects of urban development, mercury, and petrochemicals on the marine environment; effect of natural siltation and petrochemicals on shrimp and other marine life; mass-balance equations dealing with the movement of pollutants from air masses to the ocean; movement of mercury and petroleum in large "watershed areas" into the marine environment.

50. Middaugh, D.P., and W.P. Davis. 1976. IMPACT OF CHLORINATION PROCESSES ON MARINE ECOSYSTEMS. In: Water Quality Criteria Research of the U.S.

Environmental Protection Agency, Cincinnati, OH. U.S. EPA Ecological Research Series, EPA-600/3-76-079. pp. 46-82.

The use of chlorine as a disinfectant and antifouling agent is reviewed. Chemical reactions of chlorine in aquatic environments are discussed, with particular emphasis on the formation of halogenated organic constituents in freshwater and marine systems. Studies of the effect of chlorinated sewage effluents and cooling water from generating stations on marine organisms and ecosystems are summarized.

51. Richards, Norman L. 1976. RESPONSIBILITIES FOR MARINE POLLUTION RESEARCH WITHIN FEDEPAL AGENCIES OF THE UNITED STATES. In: Proceedings of the International Symposium on Marine Pollution Research, January 27-29, 1976, Environmental Research Laboratory, Gulf Breeze, FL, Samuel P. Meyers, editor, U.S. EPA Ecological Research Series, EPA-600/9-76-032. pp. 5-11.

The role of federal agencies delegated responsibilities in offshore oil exploration and development is discussed. Major programs being implemented by ERDA, NOAA, the Fish and Wildlife Service (FWS), and EPA are described, and problems related to the assessment of the potential impact of offshore oil exploration are reviewed.

52. Sikka, Harish C., Gary L. Butler, and Clifford P. Rice. 1976. EFFECTS, UPTAKE, AND METABOLISM OF METHOXYCHLOR, MIREX, AND 2,4-D IN SEAWEEDS. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/3-76-048. 39 p.

This study concerns the effects, uptake, and metabolism of mirex, methoxychlor, and 2,4-D in the seaweeds _Ulva_ sp., _Enteromorpha_ sp. and _Rhodymenia_ sp. The pesticides, at concentrations corresponding to their maximum solubility in seawater, had no significant effect on photosynthesis, protein, carbohydrate, lipid, chlorophyll, carotenoid or trace metal content of the algae. All three algae removed substantial amounts of mirex and methoxychlor from the medium, but uptake of 2,4-D was extremely low. The rate of uptake of methoxychlor was considerably greater than that of mirex. _Enteromorpha_ accumulated considerably more mirex and methoxychlor than _Ulva_ or _Rhodymenia_. Both _Ulva_ and _Enteromorpha_ failed to metabolize either mirex or 2,4-D. _Enteromorpha_ metabolized methoxychlor to a limited extent. After 7 days of incubation with carbon-labelled methoxychlor, a major portion of the label in the tissue and medium was present in unchanged methoxychlor. A small amount of radioactive metabolite, 2,2-bis (_p_-methoxyphenyl)-1,1-dichloroethylene, was detected in both the tissue and medium. In addition, medium contained 2,2-bis (_p_-hydroxyphenyl)-1,1,1-trichloroethane and four unidentified minor radioactive metabolites. Unlike _Enteromorpha_, _Ulva_ did not metabolize methoxychlor.

53. Teas, Howard J. 1976. HERBICIDE TOXICITY IN MANGROVES. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600/3-76-004. 33 p.

Effects resulting from the application of amine salts of 2,4-D and picloram are investigated with the Florida species of mangroves: white (*Laguncularia racemosa*), red (*Rhizophora mangle*), and black (*Avicennia germinans*). Treatments are applied to soil or water by aerial spray and as droplets to single leaves. Results reported for white, red, and black mangroves, respectively, are: "lethal doses"--seedlings, 2.7, 13, and 13 kg/ha; mature plants, 2.7, 13 and >53 kg/ha; "tolerance doses"--seedlings, 0.01, 5.3, 5.3 kg/ha; mature plants, 0.5, 5.3, and 53 kg/ha; "no-effect doses"--seedlings, 0.01 kg/ha all species; mature plants, <0.1, 0.5, and 2.7 kg/ha. Tests show that spray applications of 6.3 to 12.2 kg/ha to the canopy of a mixed-species forest cause partial defoliation within three weeks. Within 16 months, all white mangroves and 78 to 100% of the mature red mangroves were killed, but mature black mangroves were not. Radiocarbon-labelled picloram concentrated in dormant buds of red mangroves, indicating that the tree is killed by effects of the mixture.

54. Tyler-Schroeder, Dana Beth. 1976. STATIC BIOASSAY PROCEDURE USING GRASS SHRIMP (*PALAEMONETES* SP.) LARVAE. In: Bioassay Procedures for the Ocean Disposal Permit Program, Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-600-76-010. pp. 50-60.

Procedures are outlin[illegible] static 96-hr bioassays with the grass shrimp larvae, *Palaemonetes* sp. Three species of the genus, *P. pugio*, *vulgaris*, and *intermedius* are easily collected and maintained in the laboratory. Spawning can be induced in the laboratory by manipulating temperature and light. Developing larvae have demonstrated a greater susceptibility to polychlorinated hydrocarbons than that observed in adults or juveniles.

1975

55. Bourquin, Al W. 1975. MICROBIAL-MALATHION INTERACTION IN ARTIFICIAL SALT-MARSH ECOSYSTEMS: EFFECT AND DEGRADATION. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-660/3-75-035. 41 p.

In a simulated salt-marsh environment, malathion is degraded by the indigenous bacterial community. Bacteria capable of degrading malathion in the presence of additional nutrients increase in the sediments with increasing frequency of application and in the water column with the increasing level of treatment. Numbers of bacteria that degrade malathion as a sole carbon source are linked to the level of treatment in sediments and the frequency of treatment in the water column; however, these bacteria do not appear to play a significant role in the dissipation of malathion. Frequency of treatment apparently increases the number of malathion co-metabolizing bacteria that catalyze a more rapid dissipation of the compound, thus resulting in fewer sole carbon degraders.

The disappearance of malathion in the salt-marsh environment is influenced by both chemical and biological degradation. At temperatures below 26°C and salinities below 20 $^{o}/oo$, chemical mechanisms appear to be less important than biological degradation.

56. Bourquin, Al W., Donald G. Ahearn, and Samuel P. Meyers, editors. 1975. IMPACT OF THE USE OF MICROORGANISMS ON THE AQUATIC ENVIRONMENT. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-660/3-75-001. 259 p.

Subject of this report is examined in a symposium-workshop sponsored in April 1974 by the Environmental Research Laboratory, Gulf Breeze, to assess the possible impact of artificially introducing microbial insect control agents or oil-degrading agents into the aquatic environment. Panelists representing government, academia, and industry discuss problems related to nontarget aquatic organisms in the use of bacteria, viruses, fungi, and protozoa to control insect pests. Attention is given to the persistence of pathogens in aquatic environments and the control of weeds and other non-insect pests. Use of microorganisms to clean up oil spills in aquatic environments is also discussed.

57. Brown, Lewis R., Earl G. Alley, and David W. Cook. 1975. THE EFFECT OF MIREX AND CARBOFURAN ON ESTUARINE MICROORGANISMS. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-660/3-75-024. 47 p.

This report describes a conceptual model of the movement and disposition of pesticides in the environment. A multi-media model is built up from simple modules representing basic processes and components of air, soil, and water. More specific models are exposited for the atmospheric/terrestrial, freshwater/aquatic, and estuarine/marine environments. Through iterative operations of expansion and systematic reduction of the components and processes these models of segments of the environment can be joined to provide a holistic view of the disposition of a chemical and its attendant effects. Ultimately systems analysis and mathematical simulation techniques can be employed to evaluate the fate of a specific chemical in a particular environment. The authors emphasize the commonalities of the basic processes and components in the various environments.

58. Hansen, David J. 1975. PCB'S: EFFECTS ON AND ACCUMULATION BY ESTUARINE ORGANISMS. In: National Conference on Polychlorinated Biphenyls, November 19-21, 1975. U.S. EPA, Cincinnati, OH, EPA Ecological Research Series, EPA-560/6-75-004. pp. 282-283.

> Effects of PCB's on and accumulation by estuarine organisms in laboratory bioassays are described. Aroclors 1016, 1242, and 1254 were acutely toxic to certain estuarine organisms at concentrations greater than 10 μg/1, but these bioassays underestimated toxicities of PCB's, as shown by data from exposures that lasted longer than 2 weeks. Concentrations that were lethal to selected invertebrates and fishes in chronic exposures ranged from 0.1 to 5 μg/1. Reproduction of sheepshead minnows was impaired by concentrations of Aroclor 1254 in their eggs >5 μg/1, but this was not observed in eggs that contained up to 77 μg/g of Aroclor 1016. Bioaccumulation of PCB's in estuarine organisms generally exceeded 10^4 X the concentration in water in laboratory studies and 10^5 X in the estuary.

59. Lee, Jong H., Colin E. Nash and Joseph R. Sylvester. 1975. EFFECTS OF MIREX AND METHOXYCHLOR ON STRIPED MULLET, MUGIL CEPHALUS L. Environmental Research Laboratory, Gulf Breeze, FL. U.S. EPA Ecological Research Series, EPA-660/3-75-015. 18 p.

> The effects of two chlorinated insecticides, mirex and methoxychlor, on striped mullet, Mugil cephalus L., are studied. Test concentrations of both insecticides were 0.01, 0.1, 1.0, and 10.0 ppm in the dynamic bioassay. Young juveniles were more susceptible to mirex exposure than were older juveniles or adults. No mortalities occurred in older juveniles and adults exposed to mirex for 96 hr. For young juveniles, mortalities were highest in concentrations of 0.1 and 1.0 ppm and were less in concentrations of 0.01 and 10.0 ppm. Significant amounts of mirex residues were accumulated in the body tissues of the test fish; concentrations increased with increased environmental concentrations. Methoxychlor was more toxic to mullet than mirex. Mortalities were greater than 90% over a 96-hr period for all life stages studied at concentrations of 0.1, 1.0, and 10.0 ppm. Mortality at a concentration of 0.01 was 5.1% or less for 96 hr. Relative to mirex, small amounts of methoxychlor residues accumulated in the tissues of the test fish. Results of the experiments on eggs and larvae were inconclusive: egg survival was slightly better in mirex than in methoxychlor over a 96-hr period; larval survival was generally better in mirex than methoxychlor.

60. Walsh, Gerald E. 1975. UTILIZATION OF ENERGY BY PRIMARY PRODUCTS IN FOUR PONDS IN NORTHWESTERN FLORIDA. In: Proceedings: Biostimulation-Nutrient Assessment Workshop, October 16-17, 1973. U.S. EPA National Environmental Research Center, Corvallis, OR, EPA-660/3-75-034. pp. 249-274.

This paper describes research concerned with seasonal changes in energy utilization. The amounts of solar energy absorbed by photosynthetic processes in four small ponds in northwestern Florida in 1968 are compared with energy required for fixation of CO_2. In this investigation, blue-green algae are the dominant phytoplanketers in all ponds during most of the year and attain greatest numbers between April and October; photosynthetic quotients are highest during the blue-green algae blooms. It is hypothesized that increased production of fat may explain why the energy required for CO_2 fixation increased in the summer.

1974

61. Gillett, James W., James Hill, IV, Alfred W. Jarvinen, and W. Peter Schoor. 1974. A CONCEPTUAL MODEL FOR THE MOVEMENT OF PESTICIDES THROUGH THE ENVIRONMENT: A CONTRIBUTION OF THE EPA ALTERNATIVE CHEMICALS PROGRAM. U.S. EPA, Cincinnati, OH, Ecological Research Series, EPA-660/3-74-024. 79 p.

    This investigation relates to the chemical, physical, and microbiological fate of mirex and carbofuran in the estuarine environment and their effect(s) on important estuarine microorganisms and their activities. Chemical studies on the adsorption, fate and hydrolysis were conducted. The microbiological studies involved the use of both pure cultures and mixed cultures in a microcosm system and included 12 distinct physiological groups of microorganisms.

    Authors conclude that neither mirex nor carbofuran have a deleterious effect on estuarine bacteria under normal conditions; no evidence of bioaccumulation is found. Degradation products of both compounds are shown to be toxic to some microorganisms.

62. Schoor, W. Peter. 1974. THEORETICAL MODEL AND SOLUBILITY CHARACTERISTICS OF AROCLOR® 1254. In: Water: Problems Associated with Low-solubility Compounds in Aquatic Toxicity Tests. U.S. EPA, Cincinnati, OH, EPA-660/3-74-013. 30 p.

    A theoretical model of the behavior of substances having low water-solubility is presented and discussed with respect to aqueous bioassay. Ultracentrifugal techniques are used in an attempt to study size distributions of Aroclor® 1254 aggregates in aqueous emulsions. Results indicate strong adsorption from emulsion by surfaces and a water-solubility at 20°C of less than 0.1 μg/l in distilled water and approximately 40% of that value in water containing 30 μg/l NaCl. Implications with regard to aqueous bioassay are examined.

1973

63. Bourquin, Al W. 1973. IMPACT OF MICROBIAL SEED CULTURES ON THE AQUATIC ENVIRONMENT. In: Proceedings of the First Microbiology Seminar on Standardization of Methods. U.S. EPA Forms and Publications Center, Raleigh, NC. EPA Environmental Monitoring Series, EPA-R4-73-022. pp. 140-142.

    This paper focuses on studies related to the use of microbial seed cultures as microbiological pesticides. Need for further investigation of the impact of these pesticides on the aquatic environment is emphasized.

64. Butler, Philip A. 1973. BIOLOGICAL PROBLEMS IN ESTUARINE MONITORING. In: Proceedings of Seminar on Methodology for Monitoring the Marine Environment, Seattle, Washington, 1973. U.S. Environmental Protection Agency. Washington, DC, EPA-600/4-74-004. pp. 126-128.

    A surveillance program to assess the extent of persistent organochlorine pollution in the physical environment and in biota is discussed. Studies conducted in the National Estuarine Monitoring Program show that the uptake and retention of persistent residues in the marine environment can vary unpredictably with the environmental element sampled. Need for the careful design of surveillance or monitoring systems to provide answers to specific objectives is emphasized.

65. Wilson, Alfred J., Jr., and Jerrold Forester. 1973. METHODS AND PROBLEMS IN ANALYSIS OF PESTICIDES IN THE ESTUARINE ENVIRONMENT. In: Proceedings of Seminar on Methodology for Monitoring the Marine Environment. U.S. EPA, Washington, D.C., EPA Ecological Research Series, EPA-600/4-74-004. pp. 108-123.

    Research by the Environmental Research Laboratory, Gulf Breeze, on effects of pesticides in the marine environment is reviewed from 1958 to publication date. Analytical methods employed under the National Pesticide Monitoring Program are defined. The need for adequate analytical quality control in marine monitoring is discussed.

Journal Articles

Articles listed below have been published in scientific journals. The research described has been performed by staff of the Environmental Research Laboratory, Gulf Breeze (ERL, GB) and its Bears Bluff Field Station or by researchers aided by EPA grants or contracts administered by ERL, GB. Limited copies are available for most articles identified as a reprint through the ERL, GB Library. Other publications can be found in journals or collections maintained by college and university libraries.

1978

66. Bourquin, A.W., P.H. Pritchard, and W.R. Mahaffey. 1978. EFFECTS OF KEPONE ON ESTUARINE MICROORGANISMS. Dev. Ind. Microbiol., Vol. 19, pp. 489-497. (ERL, GB Reprint #345).

    Low concentrations of the insecticide Kepone, approaching those found in contaminated James River sediment, are shown to be inhibitory to the growth and oxygen uptake of microorganisms randomly selected from estuarine environments. No significant correlations are noted between growth inhibition by Kepone and cell morphology, Aliphatic hydro-carbon utilization, pesticide tolerance, selected enzyme activities, nitrate reduction, and urea hydrolysis. Oxygen uptake by pure cultures grown on glucose or hydrocarbons at cell densities equivalent to 10^3 - 10^4 cells/ml is shown to decrease by 60 to 100% at Kepone concentrations of 0.02 to 2.0 mg/l. Total viable counts from estuarine water or sediments grown aerobically on agar media containing 0.02 mg/l are reduced by 8 to 78%. In this study, the inhibitory effect is eliminated partially when sediment populations are grown anaerobically.

67. Butler, Philip A., Charles D. Kennedy, and Roy L. Schutzmann. 1978. Pesticide Residues in Estuarine Mollusks, 1977 versus 1972--National Pesticide Monitoring Program. Pestic. Monit. J. 12(3):99-101.

    This report summarizes 1524 analyses of juvenile fish collected semiannually in 144 estuaries nationwide from July 1972 through June 1976. Pooled samples of 25 whole fish were screened for 20 common pesticides and polychlorinated biphenyls (PCB's).

The three most common residues, DDT, PCB's, and dieldrin, were found in 39, 22, and 5% of the samples, respectively. Data indicate that estuarine pollution levels continue to decline.

68. Caldwell, R.S., D.A. Armstrong, D.V. Buchanan, M.H. Mallon, and R.E. Millemann. 1978. TOXICITY OF THE FUNGICIDE CAPTAN TO THE DUNGENESS CRAB *CANCER MAGISTER*. Mar. Biol. 48(1):11-18.

Captan did not affect the survival of Dungeness crab (*Cancer magister* Dana) zoeae exposed to 30 $\mu g\ l^{-1}$ during a chronic toxicity test lasting 69 days, but larvae were quickly killed (mean survival time = 9 days) in the same test by exposure to 450 $\mu g\ l^{-1}$ of the fungicide. Delay of molting occurred for later stages at 30 $\mu g\ l^{-1}$. Survival of juvenile crabs was not reduced by exposure to captan for 36 days at 510 $\mu g\ l^{-1}$ or, in a second test, for 80 days at 290 $\mu g\ l^{-1}$. No deaths of adults exposed for 75 days to 340 $\mu g\ l^{-1}$ of captan were observed. Captan appeared to accelerate hatching of eggs at all concentrations tested from 100 to 10,000 $\mu g\ l^{-1}$. The development from prezoeae during a 24-hr period was not inhibited by the fungicide, but at 3,300 and 10,000 $\mu g\ l^{-1}$, the two highest concentrations tested, developing zoeae exhibited a morphological deformity and were largely inactive. Under conditions in the toxicity tests, the half-life of captan was estimated to be from 23 to 54 hr. Because of the relatively low toxicity of captan to crab stages and its high rate of degradation in seawater, it is suggested that the agricultural application of captan near marine waters is not likely to affect natural crab populations or crabs in laboratory culture. Furthermore, the prophylactic use of captan as a fungicidal treatment for *Lagenidium* sp. in larval crab cultures is considered safe when used at recommended dosages.

69. Cooley, Nelson R. 1978. AN INVENTORY OF THE ESTUARINE FAUNA IN THE VICINITY OF PENSACOLA, FLORIDA. Florida Dept. of Natural Resources, St. Petersburg, FL, Florida Marine Research Publication No. 31. 119 p. (ERL, GB Contribution #102).

This first inventory of the fauna of the Pensacola Estuary, Florida, records 654 species of benthic and pelagic animals obtained by systematic collecting from 1961 through 1963 and by casual collecting in other years. Sampling dates approximate times of annual extremes and midpoints of the spring rise and autumnal decline in water temperature. Biological sampling at 6 stations located along the salinity gradient was correlated with seasonal studies of hourly variation in salinity and water temperature during a single maximum amplitude tidal cycle recorded simultaneously at all stations. Data for each species include salinity of sampling station, habitat and season in which collected, and relative abundance.

Predominate animals collected were mollusks (184 species), annelids (91 species, chiefly polychaetes), arthropods (91 species, chiefly crustaceans), and bony fishes (180 species). Spawning of a turbellarian, 7 species of mollusks, and 25 species of crustaceans and breeding of horseshoe crabs are reported, but limited data do not define the duration of any of their spawning or breeding seasons. Season, duration, and intensity of setting of larvae of oysters, barnacles, bryozoans, and serpulid worms in Santa Rosa Sound during 1962-63 and in Little Sabine Bay during 1960-63 are also reported.

70. Couch, John A. 1978. DISEASES, PARASITES, AND TOXIC RESPONSES OF COMMERCIAL PENAEID SHRIMPS OF THE GULF OF MEXICO AND SOUTH ATLANTIC COASTS OF NORTH AMERICA. U.S. Natl. Mar. Fish Serv. Fish. Bull. 76(1):1-44. (ERL, GB Reprint #283).

A reference work and review of both infectious and noninfectious diseases of commercial penaeid shrimps of the Gulf and South Atlantic region of the United States are presented. Disease is second only to predation and periodic physical catastrophes in limiting numbers of penaeid shrimps in nature and second only to nutritional and reproductive requirements in limiting aquacultural successes with penaeid shrimps.

Noninfectious disease agents in penaeid shrimps are chemical pollutants, heavy metals, and environmental stresses. Organochlorine, organophosphate, and carbamate pesticides all have adverse effects in penaeids. Fractions of petroleum, particularly the napthalenes, are very toxic to shrimp. Little other work has been done on the effects of petroleum on penaeid shrimps. Cadmium causes black gills in shrimp by killing gill cells. Mercury is accumulated by penaeids and may interfere with their osmoregulatory abilities. Many chemotheropeutic chemicals used routinely in treatment of fish diseases are toxic to shrimp at certain determined concentrations.

Spontaneous pathoses found are a benign tumor, muscle necrosis, and gas bubble disease. "Shell disease" is discussed from points of view of possible causes. A syndrome of "broken backs" is reported in penaeid shrimps for the first time. An overview is presented for general needs in penaeid shrimp health research.

71. Cripe, C.R., and B. Stokes. 1978. DEVICE TO DETECT POTENTIALLY DANGEROUS ELECTRICAL CURRENTS IN SALTWATER HOLDING TANKS. Prog. Fish-Cult. 40(2):74-75. (ERL, GB Reprint #335).

Use of 60-Hz, 120-V alternating current in a laboratory with saltwater holding tanks presents a possible hazard to personnel. An apparatus described in this paper is designed to detect a voltage differential between a container of saltwater and a ground. It activates an alarm and turns off the current to a heating element relay; the voltage remains off, and the alarm continues until a reset button is pressed.

72. Farr, James A. 1978. THE EFFECT OF METHYL PARATHION ON PREDATOR CHOICE OF TWO ESTUARINE PREY SPECIES. Trans. Am. Fish. Soc. 107(1):87-91.

Fundulus grandis, the gulf killifish, was provided a prey choice of grass shrimp, *Palaemonetes pugio*, and juvenile sheepshead minnows, *Cyprinodon variegatus*. *Fundulus grandis* consumed a greater proportion of grass shrimp when both prey species were exposed to the pesticide methyl parathion than when prey were not exposed. The relative number of shrimp eaten increased with the concentration of methyl parathion. Such an effect in an estuary could result in altered species composition and species diversity.

73. Farr, James A. 1978. ORIENTATION AND SOCIAL BEHAVIOR IN THE SUPRALITTORAL ISOPOD *LIGIA EXOTICA* (CRUSTACEA: ONISCOIDEA). Bull. Mar. Sci. 28(4):659-666.

Ligia exotica is aggregative, tending to seek out conspecifics. It is hypothesized that *Ligia* must seek new shelters repeatedly with changing tides because of their restricted water requirements, and that attraction to conspecifics already in a suitable habitat is an additional orientational mechanism to those external environmental factors influencing microhabitat selection. Experiments on object orientation demonstrated a strong tendency to move toward contrasting landmarks, the result being occupation of rocky areas on the shoreline. Brief descriptions of sexual and agonistic behavior are included.

74. Helz, George R., and Rong Y. Hsu. 1978. VOLATILE CHLORO- AND BROMOCARBONS IN COASTAL WATERS. Limnol. Oceanogr. 23(5):858-869.

Contaminated coastal waters can contain nanomolar levels of C_1 and C_2 halocarbons originating through *in situ* synthesis from chlorine and through waste discharge. Haloforms are the major volatile products formed from chlorine. In freshwaters, $CHCl_3$ dominates with lesser amounts of $CHBr_3$ and the mixed Cl-Br haloforms; however, above about 5 $g \cdot kg^{-1}$ salinity, $CHBr_3$ is virtually the only product when typical chlorine doses (10-100 μM) are used. On a molar basis, >4% conversion of chlorine to haloforms was observed in some experiments. Samples from the Back River estuary (Maryland), which receives effluent from a very large urban wastewater treatment plant, contained CH_2Cl_2, $CHCl_3$, CCl_4 $CCl_2 = CHCl$, and $CCl_2 = CCl_2$ at concentrations exceeding 1 nM. Even when winter ice cover minimized loss by volatilization, downstream mixing was nonconservative, suggesting that chemical or biological degradation processes occur. Under normal circumstances, however, volatilization followed by chemical degradation in the atmosphere is probably the most important loss mechanism. Data on possible biologic effects of these compounds are critically needed.

75. Laughlin, Roger A., Claude R. Cripe, and Robert J. Livingston. 1978. FIELD AND LABORATORY AVOIDANCE REACTIONS BY BLUE CRABS (*CALLINECTES SAPIDUS*) TO STORM WATER RUNOFF. Trans. Am. Fish. Soc. 107(1):78-86.

> A combined field and laboratory study was conducted to determine the avoidance reactions of blue crabs (*Callinectes sapidus*) to highly colored, acidic runoff from clear-cut timber areas above a productive north Florida estuary.
>
> Blue crabs of two age groups showed marked laboratory avoidance of runoff (pH 4.6, 5.8) and of test water with experimentally reduced pH. Within the pH range 4.5-7.0, there was an inverse relationship between pH and avoidance. Water color appeared to play a minor role in the avoidance reactions.
>
> Field data gave divergent results. Small crabs were abundant in areas characterized by pH levels strongly avoided under laboratory conditions. Large crabs, however, were conspicuously absent from such areas in the field, indicating possible avoidance. Factors other than pH were thought to be functional in the field distribution of the crabs. This study indicates that laboratory experiments without associated field studies may cause misleading results if applied to a determination of impact criteria.

76. Middaugh, Douglas P., and Genie Floyd. 1978. THE EFFECT OF PREHATCH AND POSTHATCH EXPOSURE TO CADMIUM ON SALINITY TOLERANCE OF LARVAL GRASS SHRIMP, *PALAEMONETES PUGIO*. Estuaries, 1(2):123-125. (ERL, GB Reprint #260).

> Groups of embryonic grass shrimp, *Palaemonetes pugio*, were exposed to 0.1 and 0.3 mg/l cadmium at 30 °/oo salinity and 25°C for the last 1, 4, or 8 days prior to hatching. Other groups of embryos were cultured in uncontaminated seawater.
>
> Prehatch exposure to cadmium is shown to have no additive effect on the sensitivity of the larvae to cadmium exposure and salinity stress for 14 days after hatching. Only one group of larvae, exposed to 0.1 mg/l cadmium for 4 days before hatching and transferred to 10 °/oo salinity water containing 0.1 mg/l cadmium after hatching, showed a significant (χ^2; $P < 0.05$) decrease in survival, compared to control survival. No significant decreases in survival are reported for any larvae transferred to 15 and 30 °/oo salinity at a pre- and posthatch cadium concentration of 0.1 mg/l.
>
> At a pre- and posthatch cadmium concentration of 0.3 mg/l, significant decreases in survival were observed for all of the larvae transferred to 10 and 15 °/oo salinity after hatching. Significant decreases in survival were observed for only 2 of the groups exposed before hatching and transferred to 30 °/oo salinity and 0.3 mg/l cadmium after hatching.

77. Middaugh, D.P., J.M. Dean, R.G. Domey, and G. Floyd. 1978. EFFECT OF THERMAL STRESS AND TOTAL RESIDUAL CHLORINATION ON EARLY LIFE STAGES OF THE MUMMICHOG FUNDULUS HETEROCLITUS. Mar. Biol. 46(1):1-8. (ERL-GB Reprint #308).

Effects of simultaneous short-term (7.5 to 60 min) thermal stress (24° to 34°C) and total residual chlorination (0.05 to 1.0 mg l^{-1}) on specific development stages of the mummichog Fundulus heteroclitus (Pisces: Cyprinodontidae) are investigated. For the embryonic stages, the total number of successfully hatched larvae was used as the criterion to measure effect. For the larval stages, survival 24 hr after exposure was used. In the embryonic stages, temperature was the most important main variable. Only one embryonic stage (gastrula) was confounded by second-order interactions (temperature x duration of exposure x total residual chlorination). Both 0-day and 7-day-old larval stages showed significant higher-order interactions for all combinations of test parameters, suggesting the presence of synergistic effects of the three main experimental variables.

78. Nimmo, D.R., R.A. Rigby, L.H. Bahner, and J.M. Sheppard. 1978. THE ACUTE AND CHRONIC EFFECTS OF CADMIUM ON THE ESTUARINE MYSID, MYSIDOPSIS BAHIA. Bull. Environ. Contam. Toxicol. 19(1):80-85. (ERL, GB Reprint #287).

Mysids, small shrimp-like crustacea, are used as practical/bioassay animals for investigating the effects of cadmium in seawater. In laboratory tests, the mysid (Mysidopsis bahia) was more sensitive to cadmium than other crustaceans tested. LC50 values were 15.5 μg/l within 96 hr and 11.3 μg/l during a 17-day life cycle; LC50's for other selected crustaceans were between 120 and 720 μg/l. Results of life-cycle bioassays with mysids can aid in establishing water quality criteria for marine and estuarine organisms.

79. Reish, Donald J., Thomas J. Kauwling, Alan J. Mearns, Philip S. Oshida, Steven S. Rossi, Frank G. Wilkes, and Marjorie J. Ray. 1978. MARINE AND ESTUARINE POLLUTION. J. Water Pollut. Control Fed. 50(6):1424-1469.

This literature review summarizes current data on the effects of pesticides on marine organisms, aquatic environmental research methods, bioaccumulation of pesticides by estuarine and marine organisms, and biota residue. Results of studies of the environmental effects of dredging and the occurrence of diseases and tissue abnormalities in fish, shellfish, and marine plants also are reported.

80. Tagatz, Marlin E., and Michael Tobia. 1978. EFFECT OF BARITE ($BaSO_4$) ON DEVELOPMENT OF ESTUARINE COMMUNITIES. Estuarine Coastal Mar. Sci. 7(4):401-407. (ERL, GB Reprint #340).

Barite ($BaSO_4$), the primary component of oil drilling muds, affected the composition of estuarine communities developed from planktonic larvae in aquaria containing sand and flowing estuarine water. Aquaria contained: sand only; a mixture (by volume) of 1 part barite and 10 parts sand; 1 part barite and 3 parts sand; or sand covered by 0.5 cm of barite. For all environments, annelids and mollusks were the numerically dominant phyla collected in a 1-mm-mesh sieve after 10 weeks exposure; a total of 3020 animals, representing 59 species, was collected. Significantly fewer animals and species ($\alpha = 0.01$) developed in aquaria sand covered by barite than in aquaria unexposed or exposed to 1 barite:10 sand. Number of animals in aquaria containing 1 barite:3 sand also differed ($\alpha = 0.05$) from that in control aquaria. Annelids were particularly affected and significantly fewer ($\alpha = 0.01$) were found in all treatments than in the control. Mollusks decreased markedly in number only in barite-covered aquaria. Barite, however, did not impede growth (as height) of the abundant clam, Laevicardium mortoni, or decrease abundance of six other phyla. Our data indicate that large quantities of this compound, as discharged in offshore oil drilling, possibly could adversely affect the colonization of benthic animals.

81. Tagatz, M.E., J.M. Ivey, H.K. Lehman, and J.L. Oglesby. 1978. EFFECTS OF A LIGNOSULFONATE-TYPE DRILLING MUD ON DEVELOPMENT OF EXPERIMENTAL ESTUARINE MACROBENTHIC COMMUNITIES. Northeast Gulf Science 2(1):35-42. (ERL, GB Reprint #370).

Drilling mud, as used in exploratory drilling for oil offshore, affected the composition of estuarine communities that developed from planktonic larvae in aquaria containing sand and flowing estuarine water. Aquaria contained: sand only; a mixture (by volume) of 1 part mud and 10 parts sand; 1 part mud and 5 parts sand; or sand covered by 0.2 cm mud. For all environments, annelids, mollusks, arthropods, and coelenterates were the numerically dominant phyla collected in a 1-mm mesh sieve after eight weeks exposure; a total of 1,025 animals, representing 45 species, was collected. Annelids and coelenterates were significantly fewer ($\alpha = 0.05$) in aquaria containing drilling mud than in the control aquaria. Arthropods were significantly affected only by mud cover over sand; mollusks also were diminished in this environment, but not significantly. Exposure to concentrations of drilling mud reduced not only the number of individuals, but also the frequency of occurrence of macrobenthic species. Thus, the average number of annelid species in 1 part mud:5 parts sand aquaria or in mud-covered aquaria was significantly less than in control aquaria. The average number of arthropod species per aquarium was also significantly less in the mud-cover exposure than in the control. Discharge of large quantities of drilling mud at levels tested in the laboratory could adversely affect the colonization of various substrata by benthic animals in nature.

82. Walsh, G.E. 1978. TOXIC EFFECTS OF POLLUTANTS ON PLANKTON. In: Principles of Ecotoxicology, G.E. Butler, editor. John Wiley & Sons, New York, NY. pp. 257-274. (ERL, GB Reprint #341).

Pollution is considered as it affects plankton communities and species. Plankton (Gr. 'wandering') is a general term for organisms that drift or swim feebly in the surface water of ponds, lakes, streams, rivers, estuaries, and oceans. It is composed of organisms with chlorophyll (phytoplankton) and animals (zooplankton). A large scientific literature deals with the effects of pollutants on planktonic species of fresh and marine waters; less has been reported about effects of pollution on plankton communities. Mathematical models can be used to predict such effects; a few simple models are cited to suggest possible effects of selected pollutants.

83. Wilson, Alfred J., and Jerrold Forester. 1978. PERSISTENCE OF AROCLOR 1254 IN A CONTAMINATED ESTUARY. Bull. Environ. Contam. Toxicol. 19(5):637-640. (ERL, GB Reprint #339).

This brief report summarizes the concentrations of PCB's in oyster tissue (Crassostrea virginica) observed from April 1969 to June 1976 at three locations in the Escambia Bay estuary, following elimination of an accidental leak of Aroclor® 1254 from an industrial site. Data show that PCB's in oyster tissue decreased after the leak was eliminated, and a steady-state concentration was reached. No Aroclor 1254 was detectable in water at stations sampled, but sediments were found to contain relatively low amounts (>0.31 ppm) in 1970 and 1971. The study demonstrates the persistence of PCB's long after point-source discharges are eliminated.

1977

84. Alexander, Shelley, and Keitz Haburay. 1977. FIRST RECORD OF OPHIOPHRAGMUS MOOREI (ECHINODERMATA, OPHIUROIDEA) IN FLORIDA COASTAL WATERS. Florida Scientist 40(3):254-255.

First sighting of the amphiurid brittle star Ophiophragmus moorei is reported in shallow coastal Gulf waters off Santa Rosa Island, approximately 2.6 km west of Pensacola Beach, FL. The known range of this species is extended 75 km eastward.

85. Bahner, Lowell H., Alfred J. Wilson, Jr., James M. Sheppard, James M. Patrick, Jr., Larry R. Goodman, and Gerald E. Walsh. 1977. KEPONE® BIOCONCENTRATION, ACCUMULATION, LOSS, AND TRANSFER THROUGH ESTUARINE FOOD CHAINS. Chesapeake Sci. 18(3):299-308. (ERL, GB Reprint #294).

Accumulation, transfer, and loss of Kepone in estuarine organisms are studied in laboratory bioassays. Results show that Kepone is bioconcentrated by oysters (Crassostrea virginica), mysids (Mysidopsis bahia), grass shrimp (Palaemonetes pugio), sheepshead minnows (Cyprinodon variegatus), and spot (Leiostomus xanthurus) from concentrations as low as 0.023 μg/l seawater. Bioconcentration factors ranged from 10 to 340 in static exposures and 900 to 13,500 in flow-through bioassays, depending on species and exposure duration. Depuration of Kepone from oysters in Kepone-free water was rapid (35% loss in 24 hr); however, depuration of Kepone was slow in crustaceans and fish, with tissue concentrations decreasing 30-50% in 24-28 days. Bioaccumulation factors (concentration of Kepone in predator/concentration in prey) at 30 days were equal (0.85 spot/mysid; 0.53 mysid/brine shrimp) in high and low concentrations tested. The initial bioconcentration of Kepone from water by plankton was the dominant source of Kepone to each member of this food chain, but data indicate that significant (>85%) quantities of Kepone transfer from prey to predatory fish.

86. Block, Ronald M., George R. Helz, and William P. Davis. 1977. THE FATE AND EFFECTS OF CHLORINE IN COASTAL WATERS: SUMMARY AND RECOMMENDATIONS. Chesapeake Sci. 18(1):97-101. (ERL, GB Reprint #344).

Objectives of The Chlorination Workshop held March 15-18, 1976, at the Center for Environmental and Estuarine Studies of the University of Maryland are summarized. Research needs regarding the chemistry and the biological impact of chlorine in coastal waters are identified. The workshop, supported by funds from EPA and the Maryland Power Plant Siting Program, is described as an extension of the Conference on Environmental Impact of Water Chlorination sponsored by EPA, the Energy, Research, and Development Administration (ERDA), and the Oak Ridge National Laboratory on October 22-24, 1975.

87. Bourquin, A.W. 1977. DEGRADATION OF MALATHION BY SALT-MARSH MICROORGANISMS. Appl. Environ. Microbiol. 33(2):356-362. (ERL, GB Reprint #291).

Numerous bacteria from a salt-marsh environment are capable of degrading malathion, an organophosphate insecticide, when supplied with additional nutrients as energy and carbon sources. Seven isolates exhibit ability (48-90%) to degrade malathion as a sole carbon source. Gas and thin-layer chromatography and infrared spectroscopy confirm malathion to be degraded via malathion-monocarboxylic acid to the dicarboxylic acid and then to various phosphorothionates. These techniques also identify desmethyl-malathion, phosphorothionates, and four-carbon dicarboxylic acids as degradation products formed as a result of phosphatase activity.

88. Bourquin, Al W. 1977. EFFECTS OF MALATHION ON MICROORGANISMS OF AN ARTIFICIAL SALT-MARSH ENVIRONMENT. J. Environ. Qual. 6(4):373-378, (ERL, GB Reprint #312).

Laboratory salt-marsh environments are treated with malathion, an organophosphate insecticide, and aerobic heterotrophic bacteria are monitored to determine changes in their microbial ecology. Several physiological activities are assayed in both treated and untreated controls, but no reliable trends in numbers of microorganisms are detected. Conversely, populations of malathion sole-carbon-degrading bacteria are found to increase significantly with increasing treatment levels. Malathion cometabolizing bacteria is found to increase significantly in the water column with increasing treatment levels and frequency of treatment.

89. Bourquin, A.W., and V.A. Przybszewski. 1977. DISTRIBUTION OF BACTERIA WITH NITRILOTRIACETATE-DEGRADING POTENTIAL IN AN ESTUARINE ENVIRONMENT. Appl. Environ. Microbiol. 32(4):411-418. (ERL, GB Reprint #323).

Attempts to isolate estuarine bacteria capable of metabolzing nitrilotriacetate (NTA) as a sole carbon source from areas within Escambia Bay, FL, were unsuccessful; however, bacteria from freshwater streams and from estuarine surface microlayers were easily adapted to degradation of NTA in freshwater medium. A Pseudomonas sp. strain (ATCC 29600), capable of growth on NTA as a sole carbon source, metabolized NTA at a reduced rate in a saline medium (15 ^{o}/oo), compared with a freshwater medium (0 to 15^{o}/oo). Microorganisms capable of degrading NTA exist in estuarine surface microlayers and in fresh subsurface waters just before entering the estuary; these data indicate an interference with NTA catabolism by some unknown factors of the estuarine environment rather than an absence of potential NTA-degrading bacteria.

90. Bourquin, A.W., M.A. Hood, and Richard L. Garnas. 1977. AN ARTIFICIAL MICROBIAL ECOSYSTEM FOR DETERMINING EFFECTS AND FATE OF TOXICANTS IN A SALT-MARSH ENVIRONMENT. Dev. Ind. Microbiol. 18:185-191. (ERL, GB Reprint #309).

An artificial laboratory environment designed to determine microbial interactions with pollutant chemicals is proposed. The system is designed to obtain maximum reproducibility between replicates by dividing a single tank into separate closed chambers. Radiolabeled toxicants are added directly to the core-chambers and monitored for metabolic breakdown.

Further information is obtained easily on changes in microbial, physiological indexes induced by the toxicants. Techniques for monitoring effects of the methyl parathion on the microbial population and the fate of this chemical are given.

91. Carpenter, James H. 1977. PROBLEMS IN MEASURING RESIDUALS IN CHLORINATED SEAWATER. Chesapeake Sci. 18(1):112.

The widely used procedure of measuring the iodine produced by reacting millimolar KI at pH4 with "residual oxidants" was found to underestimate the total oxidants in chlorinated seawater by up to 50%. Approximately 4 hr are required for complete reaction of the KI with the oxidants and rapid titrations are in serious error. The total oxidants can be measured by making the samples pH2 and KI 20 millimolar.

The slow reacting species could be some form of bromine. Ultraviolet spectra do not show any chlorine species in chlorinated seawater, but rather show the hypobromite peak. The spectra give no indication of bromine chloride complexes at pH8. Polarographic measurements do not show significant concentrations of bromate, unless the samples are exposed to sunlight. Oxyanions or chloride complexes of bromine do not appear to be the slow reacting "residual oxidant."

92. Carpenter, J.H., C.A. Moore, and D.J. Macalady. 1977. ERRORS IN DETERMINATION OF RESIDUAL OXIDANTS IN CHLORINATED SEAWATER. Environ. Sci. Technol. 11(10):992-994.

The iodometric titration procedure for residual chlorine underestimates the true values for residual oxidants in seawater by threefold or more. Chlorine added to seawater causes oxidation of the natural bromide ion. The erroneous results appear to be due to partial oxidation of iodide ion to iodate ion by bromine and hypobromous acid. Modifications of the procedure by increasing the acidity and KI concentration or the use of a back titration procedure eliminate the spuriously low results that have been false indications of a large and rapid chlorine demand in unpolluted seawater.

93. Couch, John A. 1977. ULTRASTRUCTURAL STUDY OF LESIONS IN GILLS OF A MARINE SHRIMP EXPOSED TO CADMIUM. J. Invertebr. Pathol. 29:267-288. (ERL, GB Reprint #298).

Pathologic black gills of pink shrimp, Penaeus duorarum, exposed to 763 μg/l of cadmium chloride for 15 days, are studied with transmission electron microscopy and compared with normal gills of control pink shrimp. Local as well as extensive area of cell death and necrosis were found in the distal gill filaments of black gills from cadmium-exposed shrimp. It is proposed that necrosis of specialized epithelial cells and septum cells in black gill filaments and contintiguous nonblack gill tissue could cause osmoregulatory, detoxifying, and respiratory dysfunction in crustacea, particularly in individuals undergoing environmental stress such as salinity fluctuation.

94. Couch, John A., and Lee Courtney. 1977. INTERACTION OF CHEMICAL POLLUTANTS AND VIRUS IN A CRUSTACEAN: A NOVEL BIOASSAY SYSTEM. Annu. N.Y. Acad. Sci. 298:497-504. (ERL, GB Reprint #300).

Pathogen-host interactions are investigated with a simple "host-pathogen-interaction" system. Tentative criteria of interaction are: increase in viral prevalence, increase in infection intensity, increase in mortality, and enhanced cyptopathic effects in exposed-infected shrimp as compared to control-infected shrimp. A large group of shrimp (23.3% of which had light patent Baculovirus infections) was divided equally into two groups. One group was exposed to the chemical stressor Aroclor 1254 at 0.7 parts per billion (ppb) for 35 days in flowing seawater. The other group was maintained as control in flowing seawater. Viral prevalence in exposed shrimp samples increased with time at a significantly greater rate than in control shrimp. Viral prevalence in Aroclor-exposed shrimp survivors was 75% after 35 days, whereas only 45.7% of control shrimp had patent viral infections. This finding suggests an interaction among the chemical stressor (Aroclor 1254), host, and virus. Nature or mechanism of the interaction has not been defined, but the shrimp-virus system shows promise for future bioassays to determine influence of low concentrations of pollutants on natural pathogen-host interactions.

95. Couch, John A., James T. Winstead, and Larry R. Goodman. 1977. KEPONE-INDUCED SCOLIOSIS AND ITS HISTOLOGICAL CONSEQUENCES IN FISH. Science 197:585-587. (ERL, GB Reprint #327).

Scoliosis in fish is caused by several diverse agents that possibly act on the central nervous system, neuromuscular functions, or ionic metabolism. The organochlorine pesticide Kepone induces scoliosis in the sheepshead minnow. Some effects associated with Kepone-induced scoliosis in these fish are disruption of myotomal patterns, inter- and intramuscular hemorrhage, fractured centra of vertebrae, and death. The histological syndrome of Kepone poisoning in fish and the clinical syndrome in humans suggest that the nervous system is a primary target for Kepone and that scoliosis is a secondary effect of Kepone poisoning in fish.

96. Cripe, Claude R., and R.J. Livingston. 1977. DYNAMICS OF MIREX AND ITS PRINCIPAL PHOTOPRODUCTS IN A SIMULATED MARSH SYSTEM. Arch. Environ. Contam. 5:295-303.

Three simulated marsh systems containing sediment, marsh plants, oysters, blue crabs, fiddler crabs, and two species of top minnows are described. Seawater enters each of the pools by flowing across a trough; two troughs contain mirex bait. Tidal fluctuations are simulated. Samples of water, bait, and animals are periodically analyzed. Results show that all animals concentrated mirex. Three photoproducts accumulated on the bait particles, and both oysters and one species of fish accumulated one of the photoproducts.

97. Farr, James A. 1977. IMPAIRMENT OF ANTIPREDATOR BEHAVIOR IN *PALAEMONETES PUGIO* BY EXPOSURE TO SUBLETHAL DOSES OF PARATHION. Trans. Am. Fish. Soc. 106(3):287-290. (ERL, GB Reprint #306).

    Grass shrimp, *Palaemonetes pugio*, when exposed to sublethal concentrations of methyl or ethyl parathion, become more susceptible to predation by gulf killifish, *Fundulus grandis*. An increase in spontaneous activity renders them more easily detected by a predator, and they fatigue more quickly when being pursued. Such changes in a multi-prey community could result in altered predator preferences and subsequently could change community structure and trophic relationships.

98. Goodman, Larry R. 1977. OCCURRENCE OF *ESOX NIGER* IN SANTA ROSA SOUND, FLORIDA. Florida Scientist 40(4):392. (ERL, GB Reprint #282).

    This note is the first report of *E. niger* collected from the normally saline portion of the lower Pensacola estuary. A 109-mm standard length chain pickerel was seined on 7 August 1975 from Santa Rosa Sound, in Santa Rosa County, Florida, from *Thalassia* beds about 300 m W of the N end of State Highway 399 bridge. The specimen is in the Environmental Research Laboratory Museum as catalog No. GBERL-1914.

99. Hansen, David J., Larry R. Goodman, and Alfred J. Wilson, Jr. 1977. KEPONE®: CHRONIC EFFECTS ON EMBRYOS, FRY, JUVENILE, AND ADULT SHEEPSHEAD MINNOWS (*CYPRINODON VARIEGATUS*). Chesapeake Sci. 18(2):227-232. (ERL, GB Reprint #295).

    Toxicity of Kepone to, and uptake by embryo, fry, juvenile, and adult sheepshead minnows (*Cyprinodon variegatus*) are investigated in intermittent-flow toxicity tests. Concentrations of Kepone and percentage of adult fish surviving in a 28-day exposure were: Control, 95%; 0.05 μg/l, 95%; 0.16 μg/l, 100%; 0.80 μg/l, 78%; 1.9 μg/l, 20%; and 7.8 μg/l and 24 μg/l, 0%. Concentration factors (concentrations in fish divided by concentrations measured in water) for adult fish averaged 5,200 (range 3,100 to 7,000). Symptoms of poisoning included scoliosis, darkening of the posterior one-third of the body, hemorrhaging near the brain and on the body, edema, fin-rot, uncoordinated swimming, and cessation of feeding. Adults surviving the first exposure were spawned, and the embryonic development, hatching, and survival and growth of fry and juveniles were monitored in a 36-day exposure to Kepone concentrations of 0.08, 0.18, 0.72, 2.0, 6.6, and 33 μg/l. A significant number of embryos from adult fish exposed to 1.9 μg of Kepone/l of water developed abnormally and died even when incubated in Kepone-free water. Kepone in water was not as lethal to progeny as to adults: 36-day LC50 for juveniles was 6.7 μg/l; 28-day LC50 for adults, 1.3 μg/l. However, the average standard length of juvenile fish was significantly reduced by exposure to 0.08 μg of Kepone/l of water; some fish developed scoliosis. Concentration factors in juvenile sheepshead minnows averaged 7,200 and increased from 3,600 to 20,000 as exposure concentrations decreased.

100. Hansen, David J., Steven C. Schimmel, and Jerrold Forester. 1977. ENDRIN: EFFECTS ON THE ENTIRE LIFE CYCLE OF A SALTWATER FISH, CYPRINODON VARIEGATUS. J. Toxicol. Environ. Health 3:721-733. (ERL, GB Reprint #333).

The sheepshead minnow (Cyprinodon variegatus) was continuously exposed for 23 wk to the organochlorine insecticide endrin, from the embryonic stage through hatching until adulthood and spawning. The resultant progeny were monitored to determine the effects of the toxicant on their survival, growth, and reproduction. Average measured exposure concentrations were 0 (control), 0.027, 0.077, 0.12, 0.31, and 0.72 μg/l. Embryos exposed to 0.31 and 0.72 μg/l hatched early; all fry exposed to 0.72 μg/l died by day 9 of exposure. At 0.31 μg/l, fry were initially stunted and some died. Survivors seemed unaffected until maturity, when some females died during spawning; fewer eggs were fertile and survival of exposed progeny decreased. No significant effects were observed throughout this fish's life cycle at an exposure concentration of 0.12 μg/l. Four-week-old juvenile fish accumulated 2,500 X the concentration of endrin in the exposure water; adults, 6,400 X; and their eggs, 5,700 X. The specific application factor (calculated by dividing the limits on the maximum acceptable toxicant concentration, >0.12 and <0.31 μg/l, by the concentration lethal to 50% of the juvenile fish in 96 hr, 0.34 μg/l) ranged from 0.35 to 0.91. To our knowledge this is the first toxicity test carried out through the entire life cycle of an oviporous estuarine fish. Data from this experiment, and from experiments with another estuarine fish and four freshwater fish, demonstrate that there is little difference between endrin concentrations that produce acute effects and concentrations that do not affect the fish in chronic exposures lasting 4 or more weeks.

101. Macalady, Donald L., James H. Carpenter, and Cynthia A. Moore. 1977. SUNLIGHT-INDUCED BROMATE FORMATION IN CHLORINATED SEAWATER. Science 195:1335-1337.

Chlorinated waters are being introduced into estuarine and coastal areas in increasing quantities. In such systems, the chlorine reacts with the natural bromide and ammonia to produce the highly toxic hypobromous acid, hypobromite ion, and haloamines. Sunlight causes up to 50% conversion to bromate ion, which is persistent in natural waters and has an unknown toxicity.

102. Middaugh, Douglas P., and John M. Dean. 1977. COMPARATIVE SENSITIVITY OF EGGS, LARVAE, AND ADULTS OF THE ESTUARINE TELEOSTS, FUNDULUS HETEROCLITUS AND MENIDIA MENIDIA, TO CADMIUM. Bull. Environ. Contam. Toxicol. 17(6):645-652. (ERL, GB Reprint #231).

The sensitivity of two common species of estuarine fish, the mummichog, Fundulus heteroclitus, and the Atlantic silverside, Menidia menidia, to cadmium is investigated at specific stages in their life histories. Results of tests with developing Fundulus eggs indicate that they are not very sensitive to cadmium toxicity during the first 48 hr after fertilization. In tests at both 20 and 30 °/oo salinity, the maximum mortality (non-emergence) was 54% for the highest exposure concentration of 32 mg/l cadmium. A similar resistance to cadmium was observed for developing Menidia eggs. Mortality for eggs exposed to 32 mg/l cadmium was 66% at 20 °/oo salinity and 60% at 30 °/oo salinity.

Control mortalities in excess of 10% for each of the bioassays with developing Fundulus and Menidia eggs prevented statistical treatment (probit analysis) of test results. However, a trend of decreasing mortality with decreased cadmium concentrations is indicated in each of the bioassays.

103. Middaugh, Douglas P., John A. Couch, and Allan M. Crane. 1977. RESPONSES OF EARLY LIFE HISTORY STAGES OF THE STRIPED BASS, MORONE SAXATILIS, TO CHLORINATION. Chesapeake Sci. 18(1):141-153. (ERL, GB Reprint #304).

The toxicity of total residual chlorination (TRC) to early life stages of the striped bass, Morone saxatilis, was determined by percent embryo hatchability, incipient LC50 bioassays, histopathology, and avoidance responses.

Beginning 8 to 9 hr after fertilization, developing embryos were exposed continuously to TRC in flowing water at 1.0-3.0 °/oo salinity and 18 ± 1°C; 56% of the control group (no TRC exposure) hatched. None of the embryos exposed to a measured TRC concentration of 0.21 mg/l hatched. Only 3.5% of the embryos exposed to 0.07 mg/l TRC and 23% of those exposed to 0.01 mg/l TRC hatched.

Incipient LC50 bioassays were used to determine the sensitivity of 2-, 12- and 30-day-old striped bass to concentrations of TRC in flowing water (1.0-3.0 °/oo salinity at 18 ± 1°C). The estimated incipient LC50 was 0.04 mg/l TRC for 2-day-old prolarvae, 0.07 mg/l for 12-day-old larvae, and 0.04 mg/l for 30-day-old juveniles.

Histological examination of 30-day-old juveniles that survived exposure in the incipient LC50 bioassay indicated gill and pseudobranch damage for fish exposed to 0.21 to 2.36 mg/l TRC.

Statistical analysis of avoidance tests conducted at 1.0-3.0 ‰ salinity and 18 ± 1°C with 24-day-old larvae showed significant (X^2, $P < 0.05$) and reproducible avoidance responses to measured TRC concentrations of 0.79-0.82 mg/l and 0.29-0.32 mg/l. No avoidance was indicated at TRC concentrations of 0.16-0.18 mg/l.

104. Middaugh, D.P., A.M. Crane, and J.A. Couch. 1977. TOXICITY OF CHLORINE TO JUVENILE SPOT, LEIOSTOMUS XANTHURUS. Water Res. 11:1089-1096. (ERL, GB Reprint #364).

The sensitivity of juvenile spot, Leiostomus xanthurus, to TRC in flowing seawater was investigated. Incipient LC50 bioassays, histopathology, avoidance tests, and the combined effect of thermal stress and TRC were used to assess sensitivity.

Estimated incipient LC50 values were 0.12 mg l^{-1} TRC at 10°C and 0.06 mg l^{-1} TRC at 15°C. Histological examination of spot used in the incipient LC50 bioassay at 15°C and sacrificed while alive indicated pseudobranch and gill damage occurred in individuals exposed to a measured TRC concentration of 1.57 mg l^{-1}. Spot exposed to lower concentrations of TRC, 0.02-0.06 mg l^{-1} at 15° and sacrificed alive showed no consistent tissue damage.

Spot demonstrated temperature dependent avoidance responses to TRC. At 10°C, a concentration of 0.18 mg l^{-1} was required for significant (X^2; $P < 0.05$) avoidance; at 15° and 20°C, spot showed significant avoidance of TRC concentrations as low as 0.05 mg l^{-1}.

Simultaneous exposure of spot to thermal stress (5°, 10°, or 13°C above the acclimation temperature of 15°C) at measured TRC concentrations of 0.05-0.07 and 0.34-0.52 mg l^{-1} demonstrated a significant, (X^2 with Yates correction, $P < 0.05$) increase in sensitivity to TRC with increased temperature and exposure times for some of the groups tested.

105. Schimmel, Steven C. 1977. NOTES ON THE EMBRYONIC PERIOD OF THE PINFISH LAGODON RHOMBOIDES (LINNAEUS). Florida Scientist 40(1):3-6. (ERL, GB Reprint #281).

Adult pinfish, Lagodon rhomboides, were collected during September and October, 1974 and 1975. Following a minimum one-week holding period, females were initially injected with 200 IU human chorionic gonadotropin and injected with 400 IU every second day thereafter until mature ova (0.90-0.93 mm diameter) were produced. Ova were artificially fertilized and the embryonic period (sensu Balon, 1975) described and illustrated. Emergence occurred 48 hr after fertilization at 18°C and eye pigmentation appeared 144 hr after fertilization. Larval total length at emergence was 2.3 mm; at 96 hr post-emergence, 2.7 mm; and at 120 hr post-emergence, 2.5 mm. Decrease in length and death of larvae after 96 hr post-emergence was probably due to malnutrition and subsequent infection.

106. Schimmel, Steven C., and Alfred J. Wilson, Jr. 1977. ACUTE TOXICITY OF KEPONE® TO FOUR ESTUARINE ANIMALS. Chesapeake Sci. 18(2):224-227. (ERL, GB Reprint #293).

Results of acute flow-through bioassays to determine the 96-hr toxicity of the insecticide Kepone to four estuarine species native to the James River estuary, Virginia, are reported. The species and their 96-hr LC50 values are given: grass shrimp (Palaemonetes pugio, 121 μg/l; blue crab (Callinectes sapidus), >210 μg/l; sheepshead minnow (Cyprinodon variegatus), 69.5 μg/l; and spot (Leiostomus xanthurus) 6.6 μg/l. Surviving animals were analyzed for Kepone. Average bioconcentration factors (the concentration of Kepone in tissues divided by the concentration of Kepone measured in seawater) are determined in grass shrimp, 698; blue crab, 8.1; sheepshead minnow, 1,548; and spot, 1,221.

107. Schimmel, Steven C., James M. Patrick, Jr., and Jerrold Forester. 1977. UPTAKE AND TOXICITY OF TOXAPHENE IN SEVERAL ESTUARINE ORGANISMS. Arch. Environ. Contam. Toxicol. 5:353-367. (ERL, GB Repint #269).

The organochlorine insecticide, toxaphene, was tested in flow-through bioassays to evaluate its toxicity to estuarine organisms. The organisms tested and their respective 96-hr LC50s (based on measured concentrations) are: pink shrimp (Penaeus duorarum), 1.4 μg/l; grass shrimp (Palaemonetes pugio), 4.4 μg/l; sheepshead minnow (Cyprinodon variegatus), 1.1 μg/l; and pinfish (Lagodon rhomboides), 0.5 μg/l. Toxaphene concentration estimated to reduce shell deposition in American oysters (Crassostrea virginica) by 50% (EC50) was 16 μg/l. Concentration factors (concentration of toxaphene in tissues divided by concentration measured in water) for fishes and oysters in 96 hr ranged from 3,100 to 20,600 and for shrimp, from 400 to 1,200.

Individuals from various ontogenetic stages of longnose killifish (Fundulus similis) were exposed to toxaphene for 28 days in flow-through bioasays. Toxaphene was toxic to embryos, fry, juveniles, and adult fish, but fertilization of ova in static tests was not affected by the concentrations tested (0.32 to 10 μg/l). The 28-day measured LC50s for all stages ranged from 0.9 to 1.4 μg/l. Toxaphene was accumulated in ova and other body tissues of the longnose killifish; concentration factors in ova were 1,000 to 5,500, and in whole-body tissues, 4,200 to 60,000.

108. Schimmel, Steven C., James M. Patrick, Jr., and Jerrold Forester. 1977. TOXICITY AND BIOCONCENTRATION OF BHC AND LINDANE IN SELECTED ESTUARINE ANIMALS. Arch. Environ. Contam. Toxicol. 6(2/3):355-363. (ERL, GB Reprint #288).

Flow-through, 96-hr bioassays were conducted to determine the acute toxicity of technical BHC and lindane to several estuarine animals. Test animals and their respective 96-hr lindane LC50 values were: mysid (*Mysidopsis bahia*), 6.3 µg/l; pink shrimp (*Penaeus duorarum*), 0.17 µg/l; grass shrimp (*Palaemonetes pugio*). 4.4 µg/l; sheepshead minnow (*Cyprinodon variegatus*), 104 µg/l; and pinfish (*Lagodon rhomboides*), 30.6 µg/l. The 96-hr LC50 values for pink shrimp and pinfish exposed to BHC were 0.34 and 86.4 µg/l, respectively. Two BHC bioconcentration studies were conducted with the oyster, *Crassostrea virginica*, and pinfish. After 28 days exposure, oysters bioconcentrated an average of 218 X the BHC measured in exposure water, while pinfish bioconcentrated 130 X in their edible tissues and 617 X in offal. After one week in BHC-free seawater, no detectable residues were measured in oysters or pinfish.

109. Tagatz, Marlin E., Joel M. Ivey, James C. Moore, and Michael Tobia. 1977. EFFECTS OF PENTACHLOROPHENOL ON THE DEVELOPMENT OF ESTUARINE COMMUNITIES. J. Toxicol. Environ. Health 3:501-506. (ERL, GB Reprint #310).

Pentachlorophenol affected the composition of communities of estuarine organisms developed in sand from planktonic larvae in estuarine water that flowed through ten control aquaria and ten aquaria per exposure concentration averaging 7, 76, or 622 µg/l. Annelids, arthropods, and mollusks were the numerically dominant phyla when animals were collected in a 1-mm-mesh sieve after 9 wk of exposure. Mollusks were markedly fewer at 7 µg/l; annelids and arthropods at 76 µg/l. Almost no animals occurred at 622 µg/l. The total numbers of individuals and species were significantly less ($\alpha = 0.01$) in aquaria exposed to 76 µg/l than in those unexposed or exposed to 7 µg/l.

110. Walsh, Gerald E. 1977. EXPLOITATION OF MANGAL. In: Wet Coastal Ecosystems, W.J. Chapman, editor, The Elsevier Scientific Publishing Co., Amsterdam. pp. 347-362. (ERL, GB Reprint #228).

Historical and current uses of mangroves are reviewed. Importance of mangroves as habitats, nurseries, and sources of food are emphasized. Recommendations of the Australian Conservation Foundation on use of mangal are summarized, and the need for extension of studies on the effects of pollutants on mangrove woodlands is emphasized.

111. Walsh, Gerald E., Karen A. Ainsworth, and Linda Faas. 1977. EFFECTS AND UPTAKE OF CHLORINATED NAPHTHALENES IN MARINE UNICELLULAR ALGAE. Bull. Environ. Contam. Toxicol. 18(3):297-302. (ERL, GB Reprint #302).

This paper describes studies on effects and uptake of three commercial mixtures of chlorinated napthalens in marine unicellular algae. Results show that a chlorinated naphthalene formulation containing a mixture of mono- and dichloro isomers is more toxic to marine algae than are formulations of tri-, tetra-, penta-, and hexachloro isomers.

112. Walsh, Gerald E., Karen Ainsworth, and Alfred J. Wilson. 1977. TOXICITY AND UPTAKE OF KEPONE IN MARINE UNICELLULAR ALCAE. Chesapeake Sci. 18(2):222-223. (ERL, GB Reprint #292).

Four species of marine unicellular algae were exposed to Kepone in laboratory bioassays. EC50 values after seven days' growth, in mg/l (ppm), were: Chlorococcum sp., 0.35; Dunaliella tertiolecta, 0.58; Nitzschia sp., 0.60; Thalassiosira pseudonana, 0.60. When exposed to 100 μg/l (ppb) Kepone for 24 hr, residues associated with the algae, in mg/kg (ppm) wet weight, were: Chlorococcum sp., 80; D. tertiolecta, 23; Nitzschia sp., 41; T. pseudonana, 52.

1976

113. Bahner, Lowell, and Del Wayne R. Nimmo. 1976. PRECISION LIVE-FEEDER FOR FLOW-THROUGH LARVAL CULTURE OR FOOD CHAIN BIOASSAYS. Prog. Fish-Cult. 38(1):51-52. (ERL, GB Reprint #246).

This report describes an inexpensive automatic feeder that features precise timing of a wide choice of food delivery periods and time intervals between food delivery. The feeder can also control simultaneous delivery of a variety of foods, is suitable for delivering toxicant-laden live foods, and is compatible for use in flow-through water systems. Although several automatic feeders have been described for culturing fish and crustaceans, this model is considered more versatile.

114. Cook, Gary H., and James C. Moore. 1976. DETERMINATION OF MALATHION, MALAOXON, AND MONO- AND DICARBOXYLIC ACIDS OF MALATHION IN FISH, OYSTER, AND SHRIMP TISSUE. J. Agric. Food Chem. 24(3):631-634. (ERL, GB Reprint #273).

A method is described for monitoring the presence of malathion and its metabolites in the aquatic environment. Malathion, malaoxon, malathion monoacid, and malathion diacid were determined in fish, oyster, and shrimp tissues by gas-liquid chromatography (GLC). GLC analyses were performed without cleanup by a flame photometric detector operating in the phosphorus mode. Acid compounds were methylated with diazomethane. Pinfish exposed to 75 μg/l of malathion in flowing seawater for 24 hr contained no residues of malathion or malaoxon, although the concentration of the malathion monoacid in the gut was 31.4 μg/g. The data illustrate that pinfish rapidly convert malathion to the mono- and dicarboxylic acids of malathion.

115. Cook, Gary H., James C. Moore, and David L. Coppage. 1976. THE RELATIONSHIP OF MALATHION AND ITS METABOLITES TO FISH POISONING. Bull. Environ. Contam. & Toxicol. 16(3):283-290. (ERL, GB Reprint #275).

This report describes the relation of short-term measurability of malathion and some of its metabolites in fish to poisoning of fish in the laboratory. Degree of poisoning is determined by brain acetycholinesterase inhibition and deaths in exposed populations.

116. Coppage, D.L., and T.E. Braidech. 1976. RIVER POLLUTION BY ANITCHOLINESTERASE AGENTS. Water Res. 10(1):19-24. (ERL, GB Reprint #227).

The effects of effluent discharged into the Blue River, near its confluence with the Missouri River in Kansas City, MO, by a manufacturer of organophosphate and carbamate pesticides are described. Since these pesticides act as nerve poisons by inhibiting the neurotransmitter modulating enzyme acetylcholinesterase (AChE) in the nervous system, poisoning of fishes was diagnosed by measurement of brain-AChE in fishes collected from the Missouri River upstream and downstream from the mouth of the Blue River. Chemical analyses showed substantial amounts of AChE-inhibiting pesticides in the effluent relative to their toxicities. These data indicate that the effluent is a contributing factor in the reduced brain-AChE activity of Missouri River fishes and that brain-AChE measurement in fishes is a sensitive and reliable indicator of such pollution.

117. Hansen, David J., Alfred J. Wilson, Jr., Del Wayne R. Nimmo, Steven C. Schimmel, Lowell H. Bahner, and Robert Huggett. 1976. KEPONE: HAZARD TO AQUATIC ORGANISM. Science, 193(4253):528. (ERL, GB Reprint #307).

This letter documents concern about the hazard posed by Kepone to aquatic organisms in the James River and the Chesapeake Bay. Long-term bioassays reveal that the hazard to these organisms is greatly underestimated by the 96-hr toxicity tests. Long-term exposures to Kepone have reduced survival, reproduction, or growth of the sheepshead minnows and mysids.

118. Middaugh, D.P. and P.W. Lempesis. 1976. LABORATORY SPAWNING AND REARING OF A MARINE FISH, THE SILVERSIDE *MENIDIA MENIDIA MENIDIA*. Mar. Biol. 35(4):295-300. (ERL, GB Reprints #252).

Laboratory spawning methods are described for adult silversides, *Menidia menidia menidia* (Linnaeus), collected in March 1974 and maintained in 3 recirculating seawater tanks in the laboratory. There was a significant increase (χ^2, α = 0.05) in the number of ripe males at all three feeding levels, compared to an initial field-collected group that was checked at the beginning of the conditioning period. Females also showed significant increases in ripeness at the 7 and 10% but not at the 3% feeding level. Techniques for maintaining eggs from field-ripened adults in the laboratory have been developed, and the effect of salinity on the percentage emergence of larvae determined. The highest emergence rate of larvae was 61% when eggs were maintained at 30 °/oo salinity (S). Emergence was 56% at 20 °/oo S and 47% at 10 °/oo S. The effect of delayed feeding on survival and growth of larvae was determined at 20 and 30 °/oo S and 25°C. Experimental evidence shows that survival and growth is best for larvae fed *Artemia* sp. nauplii immediately after emergence at 30 °/oo S.

119. Parrish, Patrick R., Steven C. Schimmel, David J. Hansen, James M. Patrick, Jr., and Jerrold Forester. 1976. CHLORDANE: EFFECTS ON SEVERAL ESTUARINE ORGANISMS. J. Toxicol. Environ. Health 1(4):485-494. (ERL, GB Reprint #234).

Dynamic marine toxicity tests are performed with technical grade chlordane and eastern oysters (*Crassostrea virginica*), pink shrimp (*Penaeus duorarum*), grass shrimp (*Palaemonetes pugio*), sheepshead minnows (*Cyprinodon variegatus*), and pinfish (*Lagodon rhomboides*). The 96-hr LC50s (and 95% confidence limits) based on measured concentrations of chlordane (in μg/l) are: pink shrimp, 0.4 (0.3-0.6); grass shrimp, 4.8 (4.0-6.0); sheepshead minnows, 24.5 (19.9-28.6); and pinfish, 6.4 (5.0-7.3). The 96-hr EC50 for eastern oysters was 6.2 (4.8-7.9). In a flow-through test, embryos and fry of sheepshead minnows were exposed to average measured concentrations of chlordane from 1.3 to 36.0 μg/l for 28 days. Neither fertilization success nor embryo survival was affected by the concentrations of chlordane to which these life stages were exposed. However, sheepshead minnow fry did not survive for more than 10 days in chlordane concentrations greater than 7.1 μg/l.

120. Schimmel, Steven C., James M. Patrick, Jr., and Jerrold Forester. 1976. HEPTACHLOR: UPTAKE, DEPURATION, RETENTION, AND METABOLISM BY SPOT, *LEIOSTOMUS XANTHURUS*. J. Toxicol. Environ. Health 2(1):169-178. (ERL, GB Reprint #264)

The estuarine fish, spot (*Leiostomus xanthurus*), was exposed to 0.27, 0.52, 1.01, 1.99, and 3.87 μg/l technical grade heptachlor (65% heptachlor, 22% trans-chlordane, 2% cis-chlordane, 2% nonachlor, and 9% unidentified compounds) for 24 days in a flow-through bioassay, followed by 28 days in heptachlor-free seawater. Concentrations of heptachlor, heptachlor epoxide, and trans- and cis-chlordane in edible tissues were monitored at day 3 and weekly thereafter throughout the bioassay and at the end of the postexposure period. All four chemicals were accumulated by spot. Maximum concentrations of heptachlor were observed on day 3; maximum concentrations of the other three compounds were observed on day 17. The average bioconcentration factors for heptachlor and trans-chlordane were 3,600 and 4,600, respectively. Only 10% or less of the maximum concentrations of heptachlor, heptachlor epoxide, and trans-chlordane accumulated during the exposure period remained after 28 days in pesticide-free seawater; an average of 35% of the cis-chlordane remained. Relative total amounts of heptachlor and cis-chlordane changed during the exposure and post-exposure periods. Nearly all of the heptachlor was eliminated or metabolized to its epoxide. Cis-chlordane, which averaged 4-7% of the total residues (chlordanes and heptachlors) in edible tissues during the exposure, increased to 18-23% of the total residues by the end of the postexposure period.

121. Schimmel, Steven C., James M. Patrick, Jr., and Jerrold Forester. 1976. HEPTACHLOR: TOXICITY TO AND UPTAKE BY SEVERAL ESTUARINE ORGANISMS. J. Toxicol. Environ. Health 1(6):955-965. (ERL, GB Reprint #265)

Technical-grade heptachlor (65% heptachlor, 22% trans-chlordane, 2% cis-chlordane, and 2% nonachlor) was tested in 96-hr bioassays to determine its toxicity to estuarine animals. The test organisms and the 96-hr LC50s or EC50s (based on measured concentrations in water) are as follows: American oyster (Crassostrea virginica). 1.5 µg/l; pink shrimp (Penaeus duorarum), 0.11 µg/l; grass shrimp (Palaemonetes vulgaris), 1.06 µg/l; sheepshead minnow (Cyprinodon variegatus), 3.68 µg/l; pinfish (Lagodon rhomboides), 3.77 µg/l; and spot (Leiostomus xanthurus), 0.85 µg/l. Analytical-grade heptachlor (99.8% heptachlor) and heptachlor epoxide (99%) were also studied. The analytical-grade heptachlor 96-hr LC50 for pink shrimp and spot was 0.03 µg/l and 0.86 µg/l, respectively, while that for pink shrimp exposed to heptachlor epoxide was 0.04 µg/l. Heptachlor was accumulated and some metabolized to its epoxide by all animals tested. Fish and oysters accumulated heptachlor in their tissues 2,800-21,300 times the measured concentration in water; shrimp, only 200-700 times.

122. Schoor, W.P., and S.M. Newman. 1976. THE EFFECT OF MIREX ON THE BURROWING ACTIVITY OF THE LUGWORM (ARENICOLA CRISTATA). TRANS. AMER. FISH. SOC. 105(6):700-703. (ERL, GB Reprint #268).

An inexpensive bioassay system is developed to estimate pollutant effects on a benthic animal. Mirex, a fire ant toxicant, is taken into the substrate by the burrowing and feeding activity of the lugworm, *Arenicola cristata*, and significantly affected this activity. Mirex is present in the adult worm as well as in its juvenile stage.

123. Tagatz, Marlin E. 1976. EFFECT OF MIREX ON PREDATOR-PREY INTERACTION IN AN EXPERIMENTAL ESTUARINE ECOSYSTEM. Trans. Am. Fish. Soc. 105(4):546-549. (ERL, GB Reprint #276).

Tests of 14- to 16-days' duration were conducted to determine the distribution and sublethal effects of mirex in an experimental estuarine ecosystem. The insecticide was translocated from water at concentrations of 0.011 to 0.13 µg/l to sand, plant, and animal components. An alteration of predator-prey interaction due to mirex was manifested by a significant difference (χ^2 test, $\alpha = 0.05$) in survival of grass shrimp, *Palaemonetes vulgaris*, in control and treated tanks after one, two, or three days of predation by pinfish, *Lagodon rhomboides*.

124. Tagatz, M.E., P.W. Borthwick, J.M. Ivev, and J. Knight. 1976. EFFECTS OF LEACHED MIREX ON EXPERIMENTAL COMMUNITIES OF ESTUARINE ANIMALS. Arch. Environ. Contamin. Toxicol. 4(4):435-442. (ERL, GB Reprint #229).

Experimental communities of various estuarine animals in outdoor tanks were exposed to a continuous flow of water containing mirex for 10 weeks. The mirex was leached from fire ant bait (0.3% active ingredient) by fresh water that was then mixed with saltwater to yield exposure concentrations averaging 0.038 µg/l. The experiment simulated runoff from treated land into estuarine areas. Mortality of grass shrimp (*Palaemonetes vulgaris*), pink shrimp (*Penaeus duorarum*), common mud crabs (*Panopeus herbstii*), and striped hermit crabs (*Clibanarius vittatus*) was significantly higher in tanks containing the toxicant. Mortality of ribbed mussels (*Modiolus demissus*) and American oysters (*Crassostrea virginica*) was significantly lower in treated tanks, probably because numbers of both species of crabs that ate the bivalves were reduced. Sheepshead minnows (*Cyprinodon variegatus*) were least affected by mirex. Almost all deaths occurred after 10 or more days of exposure. All exposed animals accumulated mirex, with maximum concentrations ranging from 5,500X (pink shrimp) to 73,700X (soft tissues of oysters) above the concentration in the water. Sand substratum contained mirex up to 1,500X that in the water. The study demonstrates that mirex can be leached from bait by fresh water and be concentrated by and affect survival of members in an experimental estuarine community.

125. Water Quality Committee American Fisheries Society (D. Hansen, member). 1976. A SURVEY OF EFFORTS TO ABATE WATER POLLUTION IN FISCAL 1973 BY NORTH AMERICAN AGENCIES. Fisheries 1(1):15-21. (ERL, GB Reprint #285).

> This survey examines the FY-73 manpower, funds, activities, and attitudes of natural resource agencies toward water pollution abatement and research to develop water quality criteria for aquatic life. Respondents represent 53 state agencies, 25 U.S. Federal agencies, and 13 Canadian agencies. Summarized results indicate that environmental protection activities generally comprise only a modest share of agency budgets and that funds and manpower devoted to research related to water quality criteria are comparatively small and are expended mainly in Federal laboratories.

126. Wilson, Alfred J. 1976. EFFECTS OF SUSPENDED MATERIAL ON MEASUREMENT OF DDT IN ESTUARINE WATER. Bull. Environ. Contam. Toxicol. 15(5):515-521. (ERL, GB Reprint #258).

> This study investigates the effect of suspended material on measurement of DDT in estuarine water. The efficiency of serial LLE of DDT-fortified estuarine water is assessed and the recovery rate of fortified samples is evaluated. The experiments demonstrate the pitfalls of sample fortification: liquid-liquid extraction of estuarine water immediately after fortification yielded acceptable recovery levels with all solvent systems tested; analyses several days later gave only partial recovery.

1975

127. Bahner, Lowell H., and Del Wayne R. Nimmo. 1975. A SALINITY CONTROLLER FOR FLOW-THROUGH BIOASSAYS. Trans. Am. Fish. Soc., 104(2):388-389. (ERL, GB Reprint #214).

> An electro-mechanical device has been constructed to monitor and dilute seawater to a constant salinity for flowing-water bioassays. It has been used successfully in pesticide bioassays and requires little maintenance.

128. Bahner, L.H., C.D. Craft, and D.R. Nimmo. 1975. A SALT-WATER FLOW-THROUGH BIOASSAY METHOD WITH CONTROLLED TEMPERATURE AND SALINITY. Prog. Fish-Cult. 37(3):126-129. (ERL, GB Reprint #239).

> Flow-through bioassays offer many advantages over static exposure methods. Continuously flowing seawater simulates more closely the natural estuarine or marine environment. A bioassay described in this paper is readily adaptable to a

wide variety of estuarine and marine macroinvertebrates and fishes.

129. Borthwick, Patrick W., Marlin E. Tagatz, and Jerrold Forester. 1975. A GRAVITY-FLOW COLUMN TO PROVIDE PESTICIDE-LADEN WATER FOR AQUATIC BIOASSAYS. Bull. Environ. Contam. Toxicol. 13(2):183-187. (ERL, GB Reprint #189).

A column containing granular pesticide, bait, or inert material coated with pesticide may be used to achieve realistic concentrations of pesticides in assay water without a solvent. This report shows that mirex can be introduced into flow-through aquatic bioassay systems without a solvent by means of a gravity-flow column containing mirex bait.

130. Bourquin, Al W., and S. Cassidy. 1975. EFFECT OF POLYCHLORINATED BIPHENYL FORMULATIONS ON THE GROWTH OF ESTUARINE BACTERIA. Appl. Microbiol. 29(1):125-127. (ERL, GB Reprint #217).

Polychlorinated biphenyl formulations inhibited the growth of certain estuarine bacteria. The sensitive strains, although exhibiting some similar physiological characteristics, contained both gram-positive and gram-negative bacteria.

131. Bourquin, Al W., L.A. Kiefer, N.H. Berner, S. Crow, and Donald G. Ahearn. 1975. INHIBITION OF ESTUARINE MICROORGANISMS BY POLYCHLORINATED BIPHENYLS. Dev. Ind. Microbiol. 16:256-261. (ERL, GB Reprint #230).

Over 100 isolates of representative estuarine bacteria and fungi were screened for their ability to grow in the presence of commercial preparations of polychlorinated biphenyls (PCB). Super absorbant sensitivity discs impregnated with up to 0.5 mg of PCB were placed on the surface of freshly inoculated solid media. Twenty-six bacteria, representing both gram-positive and gram-negative strains of varying morphology, showed varying degrees of sensitivity to PCB. In contrast to insensitive isolates, sensitive strains were mainly amylolytic and proteolytic. PCB had negligible effect on the growth of fungi. The sensitivity of select cultures of heterotrophic bacteria to PCB may be of considerable importance to nutrient turnover in estuarine ecosystems.

132. Coppage, David L., Edward Matthews, Gary H. Cook, and Johnnie Knight. 1975. BRAIN ACETYLCHOLINESTERASE INHIBITION IN FISH AS A DIAGNOSIS OF ENVIRONMENTAL POISONING BY MALATHION, 0,0-DIMETHYL S-(1,2-DICARBETHOXYETHYL) PHOSPHORODITHIOATE. Pestic. Biochem. Physiol. 5(6):536-542. (ERL, GB Reprint #237).

Brain acetylcholinesterase (EC 3.1.1.7) activities were compared in groups of an estuarine fish Lagodon rhomboides (pinfish) exposed in seawater to sublethal and lethal concentrations of malathion [0,0-dimethyl S-(1,2-dicarbethoxyethyl) phosphorodithioate] to determine enzyme inhibition values for diagnosis of poisoning. Lethal exposures caused greater enzyme inhibition than sublethal exposures through 72 hr. Consistent levels of enzyme inhibition (72-79% inhibition) occurred when 40-60% of replicate exposed groups were killed at 3.5, 24, 48 and 72 hr at mean concentrations of 575, 142, 92, and 58 μg/l, respectively. A mean concentration of 31 μg/l was sublethal through 72 hr exposure and caused a maximum enzyme inhibition of only 34%. The correlation of brain acetylcholinesterase inhibition with exposure and deaths is of value in diagnosing poisoning in fish populations and has been applied to actual environmental situations. Enzyme inhibition in fishes is positively correlated with spraying of an estuary with malathion.

133. Coppage, David L., and Edward Matthews. 1975. BRAIN-ACETYLCHOLINESTERASE INHIBITION IN A MARINE TELEOST DURING LETHAL AND SUBLETHAL EXPOSURES TO 1,2-DIBROMO-2,2-DICHLOROETHYL DIMETHYL PHOSPHATE (NALED) IN SEAWATER. Toxicol. Appl. Pharmacol. 31:128-133. (ERL, GB Reprint #199).

Brain-AChE inhibition by sublethal exposure in seawater is compared to brain-AChE inhibition caused by lethal exposure to determine if brain-acetylcholinesterase (AChE) inhibition in a marine teleost Lagodon rhomboides (pinfish) by an organophosphate pesticide (naled) is specific enough to diagnose anticholinesterase poisoning. A sublethal exposure did not inhibit brain-AChE as much as lethal exposure in periods of 24, 48, and 72 hr. Consistent levels of inhibition (84-89% inhibition) occurred when 40-60% of an exposed population of pinfish was killed. This correlation of brain-AChE inhibition with exposure and death in a fish population shows that brain-AChE measurements are of value in diagnosing anticholinesterase poisoning in a marine fish.

134. Couch, John A., Max D. Summers, and Lee Courtney. 1975. ENVIRONMENTAL SIGNIFICANCE OF BACULOVIRUS INFECTIONS IN ESTUARINE AND MARINE SHRIMP. Ann. N.Y. Acad. Sci. 266:528-536. (ERL, GB Reprint #253).

Biochemical and serological investigations are underway to compare the nucleic acid, virus structural proteins, and inclusion body proteins of the shrimp virus to several species of insect Baculoviruses. This paper considers the significance of the shrimp virus in regard to the ecology of its crustacean host.

135. Crow, S.A., D.G. Ahearn, W.L. Cook, and A.W. Bourquin. 1975. DENSITIES OF BACTERIA AND FUNGI IN COASTAL SURFACE FILMS AS DETERMINED BY A MEMBRANE-ADSORPTION PROCEDURE. Limnol. Oceangr. 20(4):644-646. (ERL, GB Reprint #232).

A membrane-adsorption technique for counting surface slick microbial populations is evaluated. The simple procedure gives bacterial and fungal populations several orders of magnitude greater than those previously reported for surface slicks.

136. Hansen, David J., and Steven C. Schimmel. 1975. ENTIRE LIFE-CYCLE BIOASSAY USING SHEEPSHEAD MINNOWS (CYPRINODON VARIEGATUS). In: Proposed EPA Pesticide Guidelines for Programs Registering Pesticides, U.S. Federal Register 40(123):26904-26905. (ERL, GB Reprint #267).

A procedure is proposed to provide a method of determining the effect of a material on survival of sheepshead minnow embryos and fry, their growth to adulthood, and reproductive success. Reproductive success is measured by monitoring the ability of pairs of fish to spawn naturally, their fecundity, fertilization success, and survival of embryos and fry.

137. Hansen, David J., Steven C. Schimmel and Jerrold Forester. 1975. EFFECTS OF AROCLOR® 1016 ON EMBRYOS, FRY, JUVENILES, AND ADULTS OF SHEEPSHEAD MINNOWS (CYPRINODON VARIEGATUS). Trans. Am. Fish. Soc. 104(3):584-588. (ERL, GB Reprint #206).

We investigated the toxicity of Aroclor 1016 to, and uptake by, fry and juvenile and adult sheepshead minnows (*Cyprinodon variegatus*) in intermittent-flow bioassays lasting 28 days. Survival of eggs, of fry hatched from them, and of juvenile and adult fish, apparently was not affected by 0.1, 0.32, 1.0, 3.2, 10 µg/l of Aroclor 1016 added to aquaria, but 32 and 100 µg/l killed newly hatched fry and juvenile and adult fish. Sheepshead minnows accumulated the chemical in proportion to its concentration in the test water. Fry contained 2,500 to 8,100 X the concentration of Aroclor 1016 added to the test water, adults 4,700 to 14,000 X, and juveniles 10,000 to 34,000 X. As much as 77 µg/g of Aroclor 1016 in eggs from exposed adults apparently did not affect survival of embryos and fry.

138. Hollister, Terrence A., Gerald E. Walsh, and Jerrold Forester. 1975. MIREX AND MARINE UNICELLULAR ALGAE: ACCUMULATION, POPULATION GROWTH, AND OXYGEN EVOLUTION. Bull. Environ. Contam. Toxicol. 14(6):753-759. (ERL, GB Reprint #248).

Selected estuarine unicellular algae were exposed to mirex under various conditions of salinity and nutrient concentrations to determine effects on population growth and oxygen evolution and to determine if mirex can be accumulated by the algae. Our studies show that mirex had no significant effect on population growth or oxygen evolution of algae. It was, however, accumulated from the water by algae.

139. Jensen, A.L. 1975. COMPUTER SIMULATION OF EFFECTS ON ATLANTIC MENHADEN YIELD OF CHANGES IN GROWTH, MORTALITY, AND REPRODUCTION. Chesapeake Sci. 16(2):139-142. (ERL, GB Reprint #188).

A self-regenerating dynamic pool model fitted to the Atlantic menhaden population was applied to simulate yield as a function of the parameters for growth, reproduction, and mortality. A random variable was applied to simulate random environmental fluctuations. For each combination of parameters the yield for 50 replicates of 50 generations was calculated. Under normal conditions, considerable fluctuation in yield from the menhaden population can be expected. Decrease in the growth parameter produced the largest decrease in yield and an increase in adult mortality produced the smallest decrease in yield. The combined effects of simultaneous changes in more than one parameter were approximately additive.

140. Middaugh, Douglas P., Wayne R. Davis, and Ruth L. Yoakum. 1975. THE RESPONSE OF LARVAL FISH, *LEIOSTOMUS XANTHURUS*, TO ENVIRONMENTAL STRESS FOLLOWING SUBLETHAL CADMIUM EXPOSURE. Contrib. Mar. Sci. 19:13-19. (ERL, GB Reprint #223).

The toxicity of cadmium to larval fish, *Leiostomus xanthurus*, was studied. An incipient LC50 concentration of approximately 0.2-0.3 mg/l cadmium was first estimated. Subsequent short-term sublethal tests were conducted to determine the relationship of cadmium exposure and accumulated whole body residues of the metal on the response of larval to thermal stress and low-dissolved oxygen. Results of this study indicated a significant decrease ($\alpha=0.05$, t-Test) in the critical thermal maximum (CTM) for larvae exposed to 0.5 and 0.8 mg/l cadmium for 96 hr at 20°C. Significant decreases ($\alpha=0.05$, x^2) in survival of larvae subjected to a dissolved oxygen (DO) level of 1.6 mg/l after exposure to 0.5 and 0.8 mg/l cadmium were also observed.

141. Nimmo, D.R., D.J. Hansen, J.A. Couch, N.R. Cooley, P.R. Parrish, and J.I. Lowe. 1975. TOXICITY OF AROCLOR® 1254 AND ITS PHYSIOLOGICAL ACTIVITY IN SEVERAL ESTUARINE ORGANISMS. Arch. Environ. Contam. 3(1):22-39. (ERL, GB Reprint #162).

The occurrence of high concentrations of a PCB (Aroclor 1254) in the Pensacola estuary prompted field and laboratory studies by the Environmental Research Laboratory, Gulf Breeze (EPA). Monitoring of the estuary indicates the chemical is present in all components--particularly in sediments and fishes. Residues appear to be diminishing in sediments. Toxicity tests show estuarine species sensitive at ppb concentrations in water, with a ciliate protozoan (*Tetrahymena pyriformis* W), shrimps (*Penaeus duorarum*, *P. aztecus*, and *Palaemonetes pugio*), and a fish (*Fundulus similis*) affected at or near 1.0 ppb. Tissue concentrations of Aroclor 1254 similar to those found in natural populations of shrimps from the contaminated estuary were successfully duplicated in laboratory experiments. Shrimps also concentrated the PCB from very low concentrations

(0.04 ppb) in the water. Three estuarine species demonstrated pathologic changes at tissue and cellular level after chronic exposure to the chemical. Oysters (Crassostrea virginica) developed abnormal infiltration of leukocytes in the connective tissue, spot (Leiostomus xanthurus) developed fatty changes in their livers, and shrimp (Penaeus duorarum) developed crystalloids in hepatopancreatic nuclei.

142. Schimmel, Steven C., and David J. Hansen. 1975. AN AUTOMATIC BRINE SHRIMP FEEDER FOR AQUATIC BIOASSAYS. J. Fish. Res. Board Can. 32(2):314-316. (ERL, GB Reprint #224).

An electrically operated brine shrimp feeder is described. The device may be set to cycle 1-12 times each day for tests in fish and invertebrate culture and bioassay. Major advantages of the feeder are: (1) it is readily adapted to flow-through bioassay and culture apparatuses that require equal quantities of food be delivered to animals in two or more test aquaria; and (2) the number of feedings may be recorded. The components, all readily available, cost approximately $190.

143. Schoor, W.P. 1975. PROBLEMS ASSOCIATED WITH LOW-SOLUBILITY COMPOUNDS IN AQUATIC TOXICITY TESTS: THEORETICAL MODEL AND SOLUBILITY CHARACTERISTICS OF AROCLOR® 1254 IN WATER. Water Res. 9:937-944. (ERL, GB Reprints #208a).

A theoretical model of the behavior of substances having low water-solubility is presented and discussed with respect to aqueous bioassay. Ultracentrifugal techniques are used in an attempt to study size distributions of Aroclor 1254 aggregates in aqueous emulsions. Results indicate strong adsorption from emulsion by surfaces and a water-solubility at 20°C of less than 0.1 $\mu g\ l^{-1}$ in distilled water and approximately 40% of that value in water containing 30 $g\ l^{-1}$ NaCl. Implications with regard to aqueous bioassay are discussed.

144. Smith, N.G., A.W. Bourquin, S.A. Crow, and D.G. Ahearn. 1975. EFFECT OF HEPTACHLOR ON HEXADECANE UTILIZATION BY SELECTED FUNGI. Dev. Ind. Microbiol., 17:331-336. (ERL, GB Reprint #255).

Various concentrations of heptachlor dissolved in hexadecane were added to cultures of fungi grown in yeast-nitrogen base prepared with synthetic seawater and with deionized water. Candida maltosa and Candida lipolytica showed greatest utilization of hexadecane (20-91%) whether heptachlor was present or absent. Isolates of Pichia spartinae, Cladosporium sp., Cephalosporium sp., and Penicillium sp. also utilized the hydrocarbon, but to a lesser extent. Species of Kluyveromyces failed to grow with hexadecane as a carbon source. Compared with low concentrations, high concentrations of heptachlor appeared to have a slight stimulating effect on utilization of hexadecane by C. maltosa, but had no effect with C. lipolytica.

145. Tagatz, M.E., P.W. Borthwick, and J. Forester. 1975. SEASONAL EFFECTS OF LEACHED MIREX ON SELECTED ESTUARINE ANIMALS. Arch. Environ. Contam. Toxicol. 3(3):371-383. (ERL, GB Reprint #222).

Four 28-day seasonal experiments were conducted with selected estuarine animals in outdoor tanks that received continuous flow of mirex-laden water. Mirex (dodecachlorooctahydro-1,3,4-metheno-2H-cyclobuta [cd] pentalene) leached from fire ant bait (0.3% mirex) by fresh water and then mixed with saltwater was toxic to blue crabs (Callinectes sapidus), pink shrimp (Penaeus duorarum), and grass shrimp (Palaemonetes pugio) but not to sheepshead minnows (Cyprinodon variegatus), at concentrations less than 0.53 μg/l in water. The amount of leaching was greatest in summer and least in spring. Greatest mortality occurred in summer at the highest water temperature and concentration of mirex; least mortality occurred in spring at next to the lowest temperature and at the lowest concentration. Earliest deaths of blue crabs occurred after six days of exposure and shrimps after two days. Among animals that survived for 28 days, sheepshead minnows concentrated mirex 40,800X above the concentration in the water, blue crabs 2,300X, pink shrimp 10,000X, and grass shrimp 10,800X. Sand substrata contained mirex up to 770X that in the water. Most control and exposed animals in samples examined histologically had normal tissues, but alteration in gills of some exposed fish and natural pathogens in some exposed and control crabs and shrimp were observed. The experiments demonstrate that mirex can be leached from bait by fresh water, concentrated by estuarine organisms, and can be toxic to crabs and shrimps.

1974

146. Bahner, Lowell H. 1974. A SALINITY CONTROLLER FOR FLOWING-WATER BIOASSAYS. ASB Bull. 21(2):37 (ERL, GB Reprint #200).

Salinity and temperature are rate-determining factors for many physiological functions and these variables affect the toxicity of several pesticides to marine organisms. Because some compounds that alter or interfere with osmoregulatory mechanisms in estuarine organisms appear more toxic as salinity changes, it is often desirable in estuarine bioassays (flow-through) to adjust salinity to a constant level.

A salinity controller consisting of a seawater hydrometer, photocell detector, and a relay controlled by an electronic amplifier has been developed to monitor and adjust salinity continuously in flow-through systems. The controller regulates electrical pumps or valves to adjust salinity within ± 1% of the desired level, and, with minor modifications, can control temperature, water height, or light intensity.

147. Borthwick, Patrick W. 1974. A CLINICAL CENTRIFUGE TUBE FOR SMALL BLOOD SAMPLES. Prog. Fish-Cult. 36(3):184. (ERL, GB Reprint #238).

In many microanalytical procedures (e.g. electrophoresis), only a few microliters of serum are needed, but the serum must be free of other blood components. A simple and inexpensive device is described for separating components of small amounts of blood in a clinical-type centrifuge.

148. Borthwick, P.W., G.H. Cook, and J.M. Patrick, Jr. 1974. MIREX RESIDUES IN SELECTED ESTUARIES OF SOUTH CAROLINA--June 1972. Pestic. Monit. J. 7(3/4):144-145. (ERL, GB Reprint #168).

Estuarine sediments, crabs, shrimps, and fishes were collected in June 1972 at 11 stations 2 years after aerial applications of mirex bait for control of fire ants in coastal areas near Charleston, SC. These stations had previously been monitored (October 1969 to June 1971) when levels of mirex in animal samples were: crabs, 0-0.60 ppm; shrimps, 0-1.3 ppm; and fishes, 0-0.82 ppm.

The recent study showed that mirex was present in three species of fishes (white catfish, 0.021 ppm; bluegill, 0.047 ppm; carp, 0.12 ppm) and blue crabs (0.026 ppm) at two freshwater stations. However, mirex was not detected in 36 animal samples, most of which were taken from nine saline stations in the estuaries after a period of restricted use of the pesticide. Analysis of bottom sediment samples at all stations detected no mirex. The lower limit of detection for mirex was 0.01 ppm.

149. Cooley, Nelson R. 1974. OCCURRENCE OF SNOOK ON THE NORTH SHORE OF THE GULF OF MEXICO. Florida Scientist 37(2):98-99. (ERL, GB Reprint #192).

The known range of snook is extended about 100 miles westward to Santa Rosa Sound.

150. Coppage, David L., and Edward Matthews. 1974. SHORT-TERM EFFECTS OF ORGANOPHOSPHATE PESTICIDES ON CHOLINESTERASES OF ESTUARINE FISHES AND PINK SHRIMP. Bull. Environ. Contam. Toxicol. 11(5):483-488. (ERL, GB Reprint #169).

This report concerns AChE inhibitory effects of short-term laboratory exposures of four species of estuarine fishes and a commercial shrimp to malathion. The acetylcholine hydrolyzing enzymes from brains of spot (*Leiostomus xanthurus*; 65-150 mm total length), pinfish (*Lagodon rhomboides*; 65-125 mm), Atlantic croaker (*Micropogon undulatus*; 85-150 mm), and sheepshead minnows (*Cyprinodon variegatus*; 45-70 mm), and the ventral nerve cord (VNC) of pink shrimp (*Penaeus duorarum*; 78-122 mm) were characterized and assayed. Relatively consistent levels of AChE inhibition occurred in fishes even with different compounds and different species. The survivors of populations of fish in which 40-60% were killed by exposure to organophosphate pesticide had mean brain AChE reductions of 70-96%. These inhibitions indicate that mean reductions in AChE activity of about 80% are critical in short-term organophosphate poisoning of the fishes tested and possibly to fishes in general. Specific levels of reduction of AChE show that it is unnecessary to rely on the dubious interpretation of residues alone to determine poisoning and cause of "kills" in the environment.

151. Couch, John A. 1974. AN ENZOOTIC NUCLEAR POLYHEDROSIS VIRUS OF PINK SHRIMP: ULTRASTRUCTURE, PREVALENCE, AND ENHANCEMENT. J. Invertebr. Pathol. 24(3): 311-331. (ERL, GB Reprint #215).

A nuclear polyhedrosis virus exists in pink shrimp, *Penaeus duorarum*, from wastes of the northern Gulf of Mexico. This virus is rod-shaped, 269 nm long, and possesses an outer envelope surrounding its nucleocapsid. The nucleocapsid is 50 nm in diameter. The virus occurs in nuclei of host hepatopancreatic and midgut cells, and is both free in the nucleus and occluded within pyramidal-shaped polyhedral inclusion bodies (PIB's). Histochemically and ultrastructurally, the shrimp PIB's appear to be ribonucleoprotein and in fine structure bear close resemblance to polyhedral inclusion bodies of *Baculovirus* species from insects. However, the lattice line-to-line spacing is greater than that usually reported for insect PIB's. In limited experiments, shrimp fed heavily infected hepatopancreatic tissues had much higher mortality than controls fed only fish. The virus appears to be enzootic in pink shrimp in nature. Cytopathological changes in infected cells of shrimp appear similar to those in insects infected with certain species of *Baculovirus*. The name *Baculovirus penaei* n. sp. is proposed for the shrimp virus.

152. Couch, John A. 1974. FREE AND OCCLUDED VIRUS, SIMILAR TO *BACULOVIRUS*, IN HEPATOPANCREAS OF PINK SHRIMP. Nature 247 (5438):229-231. (ERL, GB Reprint #213).

Rod-shaped virus particles and related inclusion bodies in cells observed in pink shrimp (*Penaeus duorarum*) experimentally exposed to the polychlorinated (PCB) Aroclor 1254 are described. Their similarity is compared with certain noninclusion viruses and with nuclear polyhedrosis viruses of the *Baculovirus* group previously described only from insects and mites. A close relationship of the shrimp virus to the *Baculovirus* group is demonstrated.

153. Couch, John A. 1974. PATHOLOGICAL EFFECTS OF *UROSPORIDIUM* (HAPLOSPORIDA) INFECTION IN MICROPHALLID METACERCARIAE. J. Invertebr. Pathol. 23:389-396. (ERL, GB Reprint #211).

Extensive pathological changes occur in *Megalophallus* metacercariae as a result of natural infections by the haplosporidan hyperparasite *Urosporidium crescens*. Infected and uninfected metaceriae, recovered from blue crabs from Chincoteague Bay, MD, are compared histologically in regard to condition of metacerearial cyst wall, tegument, and specialized parenchymal cells. Changes from normal found in heavily infected metacercariae are: (1) suppression and replacement of possible secretory and parenchymal cells by the hyperparasite, (2) lack of reticulin stomata, polysaccharides and acid mucopolysaccharides, (3) reduction in thickness of cyst wall, tegumental, and connective tissue structure, and (4) loss of mobility and resistance to mechanical pressures. Though severe pathological changes occur in heavily infected metacercariae, most infected metacercariae remain viable within the blue crab and thereby serve as a vector for *Urosporidium* until the death of the blue crab. At the time of the crab's death and disorganization, infected metacercariae rupture and release spores of the hyperparasite.

154. Davies, Tudor T., and Nelson A. Thomas. 1974. THE U.S. CHEMISTRY-BIOLOGY PROGRAM IN THE INTERNATIONAL FIELD YEAR FOR THE GREAT LAKES. Mar. Tech. Soc. J. 8(1):23.

This paper describes the operation and methods of the Chemistry-Biology Program for the Great Lakes in the International Field Year. Three major objectives are described for the multidisciplinary program: material balance studies, evaluation of the current ecologic status of the lake, and the development of predictive mathematical models.

155. Duke, Thomas W. 1974. CRITERIA FOR DETERMINING IMPORTANCE AND EFFECTS OF PESTICIDES ON THE MARINE ENVIRONMENT: A BRIEF OVERVIEW. Mar. Tech. Soc. J. 8(1):21-22. (ERL, GB Reprint #180).

Criteria developed to assess the effect of pesticides through laboratory research, experimental ecosystems, and environmental studies are described. An example is presented for the use of laboratory bioassays and field observations to better understand the impact of a particular pesticide on the marine environment. Need for development of predictive models to assess possible effects of specific environmental stresses is emphasized.

156. Hansen, David J. 1974. AROCLOR® 1254: EFFECT ON COMPOSITION OF DEVELOPING ESTUARINE ANIMAL COMMUNITIES IN THE LABORATORY. Contrib. Mar. Sci. 18:19-33. (ERL, GB Reprint #164).

Aroclor® 1254, a polychlorinated biphenyl (PCB), affected the composition of communities of estuarine animals that developed from planktonic larvae in saltwater that flowed through 10 control aquaria and 10 aquaria contaminated with 0.1, 1 or 10 μg/l of this PCB. Communities that developed in control aquaria and aquaria that received 0.1 μg/l of PCB in water for four months were dominated (>75%) by arthropods, primarily the amphipod *Corophium volutator*. In aquaria receiving 1 and 10 μg/l, the number of arthropods decreased and the number of chordates, primarily the tunicate *Mogula manhattensis*, increased; over 75% of the animals in 10 μg/l aquaria were tunicates. Numbers of phyla, species, and individuals (particularly amphipods, bryozoans, crabs, and mollusks) were decreased in this PCB, but there was no apparent effect on the abundance of annelids, brachiopods, coelenterates, echinoderms, or nermerteans. The Shannon-Weaver index of species diversity was not altered by Aroclor 1254.

157. Hansen, D.J., P.R. Parrish, and J. Forester. 1974. AROCLOR 1016: TOXICITY TO AND UPTAKE BY ESTUARINE ANIMALS. Environ. Res. 7:363-373. (ERL, GB Reprint #172).

Bioassays were conducted to determine the acute toxicities of the polychlorinated biphenyl (PCB) Aroclor 1016 in flowing seawater to American oysters (*Crassostrea virginica*), brown shrimp (*Penaeus aztecus*), grass shrimp (*Palaemonetes pugio*), and pinfish (*Lagodon rhomboides*), and to determine its chronic toxicity to, and uptake and retention by, pinfish. Acute 96-hr EC50s or LC50s were: oysters, 10.2 μg/l; brown shrimp, 10.5 μg/l; grass shrimp, 12.5 μg/l. The PCB was not toxic to pinfish at 100 μg/l for 96 hr, but significant mortality occurred when pinfish were exposed to 32 μg/l of Aroclor 1016 for 42 days. Pinfish exposed to 1 μg/l for 56 days accumulated the chemical with maximum concentrations attained in whole-fish by 21 to 28 days. Maximum whole-body residue (wet weight) was 17,000 X the nominal concentration in test water. Tissue alterations, such as severe vacuolation in the pancreatic exocrine tissue surrounding the portal veins, occurred in pinfish exposed to 32 μg/l of Arolcor 1016 for 42 days.

158. Hansen, D.J., S.C. Schimmel, and E. Matthews. 1974. AVOIDANCE OF AROCLOR® 1254 BY SHRIMP AND FISHES. Bull. Environ. Contam. Toxicol. 12(2):253:256. (ERL, GB Reprint #181).

Some invertebrates possess the ability to avoid toxic pollutants in water. This paper describes laboratory studies conducted to determine if pink shrimp (*Penaeus duorarum*), grass shrimp (*Palaemonetes pugio*), pinfish (*Lagodon rhomboides*), sheepshead minnows (*Cyprinodon variegatus*) and mosquitofish (*Gambusia affinis*) could avoid water contaminated with 0.001, 0.01, 0.1, 1, or 10 mg/l of the polychlorinated biphenyl (PCB).

159. Jensen, A.L. 1974. LESLIE MATRIX MODELS FOR FISHERIES STUDIES. Biometrics, 30(3):547-551. (ERL, GB Reprint #183).

Two modifications of the Leslie matrix model are developed. In the first modification the egg stage as well as the age groups of a fish population are included in the vector of state. In the second modification only the recruited members of the population are included in the vector of state.

160. Jensen, A.L. 1974. PREDATOR-PREY AND COMPETITION MODELS WITH STATE VARIABLES: BIOMASS, NUMBER OF INDIVIDUALS, AND AVERAGE INDIVIDUAL WEIGHT. J. Fish. Res. Board Can. 31(10):1669-1674. (ERL, GB Reprint #184).

Applying the identity that biomass equals number of individuals multiplied by average individual weight, simultaneous equations for change with respect to time in biomass, number of individuals, and average individual weight are obtained for Kostitzin's predator-prey equations and for the Lotka-Volterra competition equations. By the same procedure applied here, simultaneous equations for these three variables can be obtained for other predator-prey and competition equations. These equations can be applied to determine the biomass, number of individuals, and average individual weight of interacting fish populations under different rates of exploitation.

161. Middaugh, Douglas P., and Ruth L. Yoakum. 1974. THE USE OF CHRIONIC GONADOTROPIN TO INDUCE LABORATORY SPAWNING OF THE ATLANTIC CROAKER, *MICROPOGON UNDULATUS*, WITH NOTES ON SUBSEQUENT EMBRYONIC DEVELOPMENT. Chesapeake Sci. 15(2):110-114.

The feasibility of spawning and rearing the Atlantic croaker, *Micropogon undulatus*, is examined in the laboratory. Adult croaker were collected during mid-October 1972, placed in flowing seawater holding tanks, and administered injections of either 125 or 250 I.U. of chorionic gonadotropin three times per week for three weeks. An apparent period of latency (6-7 days) was observed between the initial hormone injections and successful ovulation. Fish dosed at the 125 I.U. level were successfully spawned and eggs and larval development monitored. Larvae were carried through to 4 days after hatching when mass mortalities occurred, apparently as a result of nutritional deficiencies.

162. Nimmo, D.R., J. Forester, P.T. Heitmuller, and G. Cook. 1974. ACCUMULATION OF AROCLOR® 1254 IN GRASS SHRIMP (*PALAEMONETES PUGIO*) IN LABORATORY AND FIELD EXPOSURES. Bull. Environ. Contam. & Toxicol. 11(4):303-308. (ERL, GB Reprint #170).

Results of several experiments on chronic toxicity of Aroclor 1254 to *Palaemonetes pugio*, an estuarine grass shrimp, are reported. In this investigation, test species are exposed in the laboratory and to Aroclor 1254-contaminated sediments in Escambia Bay, near Pensacola, FL.

163. Parrish, Patrick R., David J. Hansen, John A. Couch, James M. Patrick, Jr., and Gary H. Cook. 1974. EFFECTS OF THE POLYCHLORINATED BIPHENYL, AROCLOR® 1016, ON ESTUARINE ANIMALS. ASB Bull. 21(2):74. (ERL, GB Reprint #196).

Acute toxicity and rate of uptake and depuration of the polychlorinated biphenyl (PCB), Aroclor® 1016, were determined for certain estuarine animals in flowing seawater bioassays. The 96-hr EC50s were: American oyster (*Crassostrea virginica*), 10.2 µg/l; brown shrimp (*Penaeus aztecus*), 10.0 µg/l; and grass shrimp (*Palaemonetes pugio*), 9.1 µg/l. Pinfish (*Lagodon rhomodies*) did not died when exposed to 100 µg/l for 96 hr, but significant mortality occurred when pinfish were exposed to 32 µg/l for 42 days. Further, alterations in the pancreatic exocrine tissue surrounding the portal veins occurred in pinfish from the 42-day exposure. Maximum whole-body residue (wet-weight) in pinfish was 17,000 X the nominal concentration in test water and whole-body residue after a 56-day depuration period in PCB-free water decreased 61%. Oysters exposed to 10 µg/l for 84 days accumulated the chemical 13,000 X the concentration in test water and no PCB residue was detectable after a 56-day depuration period.

164. Schimmel, Steven C., David J. Hansen and Jerrold Forester. 1974. EFFECTS OF AROCLOR® 1254 ON LABORATORY-REARED EMBRYOS AND FRY OF *CYPRINODON VARIEGATUS*. ASB Bull. 21(2):81. (ERL, GB Reprint #207).

Eggs of the sheepshead minnow (*Cyprinodon variegatus*) were artificially fertilized (wet method) and maintained at 15° to 30°C and 0 to 35 ^{o}/oo to determine efficient culture conditions. Fertilization was not affected within the temperature or salinity ranges tested, but hatching success was greatest (χ^2; $\alpha = 0.01$) within the 24° to 35°C range and 15 ^{o}/oo to 30 ^{o}/oo range.

Artifically fertilized sheepshead minnow eggs were exposed to logarithmic series of concentrations of the polychlorinated biphenyl (PCB), Aroclor 1254, (0.1 to 10 µg/l) in seawater averaging 30°C and 24 ^{o}/oo in a flow-through bioassay. Fertilization was not affected, but significantly fewer embryos developed in the 10 µg/l. Fry were more susceptible to this PCB than were embryos, juveniles, or adults.

165. Schimmel, Steven C., David J. Hansen, and Jerrold Forester. 1974. EFFECTS OF AROCLOR® 1254 ON LABORATORY-REARED EMBRYOS AND FRY OF SHEEPSHEAD MINNOWS (*CYPRINODON VARIEGATUS*). Trans. Am. Fish. Soc. 103(3):582-586. (ERL, GB Reprint #175).

Eggs of the sheepshead minnow (Cyprinodon variegatus) were artifically fertilized and maintained at temperatures from 15 to 35°C and in salinities from 0 to 35 ‰ to determine efficient culture conditions. Fertilization was not affected by temperature or salinity ranges chosen, but hatching success was greatest (X^2; $\alpha = 0.01$) at a temperature range of 24 to 35°C and a salinity range of 15 to 30 ‰.

Artificially fertilized sheepshead minnow eggs were exposed to logarithmic concentrations of Aroclor 1254 (10.0 to 0.1 µg/l) in seawater averaging 30°C and 24‰ in a flow-through bioassay. Fertilization was not affected but significantly fewer embryos developed in the 10.0 µg/l concentration, and fewer fry survived in concentrations greater than 0.1 µg/l. Fry were more susceptible to Aroclor 1254 than were embryos, juveniles, or adults.

166. Schoor, Wilhelm P. 1974. ACCUMULATION OF MIREX-^{14}C IN THE ADULT BLUE CRAB (CALLINECTES SAPIDUS). Bull. Environ. Contam. Toxicol. 12(2):136-137. (ERL, GB Reprint #190).

Carrier-solubilized mirex has been shown to be absorbed from a disperse aqueous system by juvenile and larval stages of the blue crab. Since in both cases only whole-body residues were determined, it was thought to be of interest to establish the actual distribution of mirex in the tissues.

167. Schoor, W.P. 1974. SOME ASPECTS OF MYOSIN ADENOSINE TRIPOSPHATASE OF PINK SHRIMP (PENAEUS DUORARUM). Comp. Biochem. Physiol. 49B:375-379. (ERL, GB Reprint #163).

1. Myosin ATP'ases of shrimp and rabbit muscle behave similarily except at temperatures above 30°C where the activity in shrimp started to decline rapidly. 2. There is a correlation between the effects of temperature on myosin ATP'ase and behavior of shrimp in nature; this compares well with similar observations in crayfish. 3. Data obtained emphasize that under certain conditions caution must be used in determining initial enzymatic activities.

168. Tagatz, M.E., P.W. Borthwick, G.H. Cook, and D.L. Coppage. 1974. EFFECTS OF GROUND APPLICATIONS OF MALATHION ON SALT-MARSH ENVIRONMENTS IN NORTHWESTERN FLORIDA. Mosq. News 34(3):309-315. (ERL, GB Reprint #179).

Effects of thermal fog [6 wt. oz/acre (420 g/ha)] and ULV aerosol spray [0.64 fl. oz/acre (57 g/ha)] applications of malathion 95 (o,o-dimethyl phosphorodithioate of diethyl mercaptosuccinate) on salt-marsh environments near Pensacola Beach, FL, are investigated. Studies are conducted on selected plots after each of three treatments with a portable thermal fogger and three ultra low volume (ULV) sprays with a truck-mounted generator. The ULV sprays are typical of usual mosquito-control operations.

Deaths due to malathion were not observed among confined blue crabs, Callinectes sapidus; grass shrimps, Palaemonetes vulgaris and P. pugio; pink shrimp, Penaeus duorarum; or sheepshead minnows, Cyprinodon variegatus. Brain acetylcholinesterase activity was not reduced in confined C. variegatus exposed to one or more treatments. Confined animals and the snail, Littorina irrorata, contained no measurable malathion at our limit of detectability. The chemical was not detected in sediment, but concentrations as high as 4.10 ppm were found in Juncus sp., trace amounts persisting as long as 14 days (>0.05 but <0.10 ppm). Highest concentration in marsh water after fogging was 5.2 ppb; after ULV spraying, 0.49 ppb. For each method of application, only trace amounts (>0.1 but <0.3 ppb) persisted in marsh water as long as 1 day.

169. Walsh, Gerald E., Terrence A. Hollister, and Jerrold Forester. 1974. TRANSLOCATION OF FOUR ORGANOCHLORINE COMPOUNDS BY RED MANGROVE (RHIZOPHORA MANGLE L.) SEEDLINGS. Bull. Environ. Contam. Toxicol. 12(2):129-135. (ERL, GB Reprint #193).

The translocation of the insecticides dieldrin, methoxychlor, and mirex and the polychlorinated biphenyl (PCB) Arolcor® 1242 by red mangrove seedlings was investigated. Mangrove seedlings from the field were found to contain DDD, dieldrin, and PCB's. In the laboratory, mangrove seedlings translocated dieldrin, methoxychlor, mirex, and Aroclor 1242 from soil to various plant parts. Dieldrin was detected in hypocotyls and leaves of seedlings exposed to application rates of 0.06 kg/ha and above; methoxychlor in hypocotyls at rates of 0.28 kg/ha and above; Aroclor 1242 in hypocotyls and leaves at rates of 0.56 kg/ha and above; and mirex in roots, hypocotyls, stems, and leaves only at the highest treatment rate of 11.20 kg/ha.

The data show that these persistent organochlorine compounds can be translocated to seedlings. If the compounds are present in the natural mangrove environment, it is possible that they could enter seedlings and pass to higher trophic levels when seedlings are eaten by estuarine organisms.

1973

170. Borthwick, P.W., T.W. Duke, A.J. Wilson, Jr., J.I. Lowe, J.M. Patrick, Jr., and J.C. Oberheu. 1973. ACCUMULATION AND MOVEMENT OF MIREX IN SELECTED ESTUARIES OF SOUTH CAROLINA, 1969-71. Pest. Monit. J. 7(1):6-26. (ERL, GB Reprint #156).

Collections of background and periodic posttreatment samples of water, bottom sediments, shrimp, crabs, fish, and estuary-dependent birds and mammals are analyzed for mirex with electron-capture gas chromatography. The data reveal that (1) mirex is translocated from treated lands and high marsh to estuarine biota--all animal classes sampled contained mirex: and (2) biological concentration of mirex occurs--especially in predators such as racoons and birds. Mirex residue ranges for respective sample categories were: water (<10.01 ppb); sediment (0-0.07 ppm); crabs (0-0.60 ppm); fishes (0-0.82 ppm); shrimps (0-1.3 ppm); mammals (0-4.4 ppm); and birds (0-17.0 ppm). No mass mortalities were observed during the study.

171. Butler, Philip A. 1973. ORGANOCHLORINE RESIDUES IN ESTUARINE MOLLUSKS, 1965-72--NATIONAL PESTICIDE MONITORING PROGRAM. Pestic. Monit. J. 6(4):238-362. (ERL, GB Reprint #155).

This paper describes the development of the national program for monitoring estuarine mollusks in 15 coastal States and reports the findings for the period 1965-72. Analyses of 8,095 samples for 15 persistent organochlorine compounds show that DDT residues were ubiquitous; the maximum DDT residue detected was 5.39 ppm. Dieldrin was the second most commonly detected compound with a maximum residue of 0.23 ppm. Endrin, mirex, toxaphene, and polychlorinated biphenyls were found only occasionally. Results indicate a clearly defined trend towards decreased levels of DDT residues, beginning in 1969-70. At no time were residues observed of such a magnitude as to imply damage to mollusks; however, residues were large enough to pose a threat to other elements of the biota through the processes of recycling and magnification.

172. Cooley, Nelson R. James M. Keltner, Jr., and Jerrold Forester. 1973. THE POLYCHLORINATED BIPHENYLS, AROCLORS® 1248 and 1260: EFFECT ON AND ACCUMULATION BY TETRAHYMENA PYRIFORMIS. J. Protozool. 20(3):443-445. (ERL, GB Reprint #158).

Effects of 2 polychlorinated biphenyls, Aroclor 1248 and 1260, on axenic *Tetrahymena pyriformis* strain W were investigated and compared with published data on Aroclor 1254. Aroclors 1248 and 1260 at 1 mg/l in the presence of 0.1% (v/v) polyethylene glycol 200 reduced significantly ($P < 0.005$) growth rates and 96-hr populations of *T. pyriformis* grown at 26°C. Both toxicants were 0.001 as toxic as Aroclor 1254. Ciliates were exposed for 7 days to concentrated Aroclors 1248 40X, 1254 60X, and 1260 79X over initial concentrations in the media. Accumulation of Aroclors increased with increased chlorination. It is suggested that if levels in the environment reached those used in these studies, the chief ecologic effect of Aroclor 1254 would be reduction of availability of the ciliates as food and as nutrient regenerators, but with Aroclors 1248 and 1260, this effect would be secondary to accumulation of the toxicants by the ciliates. Accumulation of polychlorinated biphenyls by ciliates would permit the toxicants to enter aquatic food chains. Thus the compounds could exert toxic effects at higher trophic levels.

173. Couch, John A. 1973. ULTRASTRUCTURAL AND PROTARGOL STUDIES OF LAGENOPHRYS CALLINECTES (CILIOPHORA: PERITRICHIDA). J. Protozool. 20(5):638-647. (ERL, GB Reprint #220).

Ultrastructural and protargol studies reveal that the trophont of *Lagenophrys callinectes*, though highly specialized, generally conforms to the basic peritrich structural pattern.

Features described for *L. callinectes* trophonts unique for the genus are the fine structure and arrangement of the lorica and lips, the attachment organelle of the peristomial cytoplasm, its attachment to the loricastome walls, and the arrangement of the aboral kinetosomes of the trophent. Lack of a distinct scopularized region and of a ventral lorica wall also characterize *L. callinectes* trophonts. The 4-row terminal peniculus, as revealed by protargol staining, differs from the 6-row terminal peniculus of *L. nassa* suggesting that the patterns of infundibular structure, as revealed by protargol, should be useful in future taxonomic studies of *Lagenophrys* species.

174. Duke, Thomas W. 1973. REVIEWS: RADIOACTIVITY IN THE MARINE ENVIRONMENT. Trans. Am. Fish Soc. 102(1):197-198. (ERL, GB Reprint #173).

The report, RADIOACTIVITY IN THE MARINE ENVIRONMENT by the National Academy of Sciences, is reviewed. The report summarizes new information acquired about radionuclides in the marine environment since publication of a report on the subject by the National Academy of Sciences-National Research Council (NAS-NRC) in 1957. W. H. Freeman and Co., California, is publisher for the report described as a valuable environmental reference.

175. Hansen, David J., Steven C. Schimmel, and James M. Keltner, Jr. 1973. AVOIDANCE OF PESTICIDES BY GRASS SHRIMP (PALAEMONETES PUGIO). Bull. Environ. Contam. Toxicol. 9(3):129-133. (ERL, GB Reprint #147).

Crustaceans are usually more sensitive to pesticides, particularly insecticides, than are fishes, but little is known about their ability to avoid pesticide pollution. This paper describes a study to evaluate the capacity of the euryhaline grass shrimp, *Palaemonetes pugio*, to avoid DDT, endrin, Dursban, malathion, Sevin, and 2,4-D. This shrimp was selected because of its importance in the food web and its abundance in waters near the Environmental Research Laboratory, Gulf Breeze, FL.

176. Hollister, Terrence A., and Gerald E. Walsh. 1973. DIFFERENTIAL RESPONSES OF MARINE PHYTOPLANKTON TO HERBICIDES: OXYGEN EVOLUTION. Bull. Environ. Contam. & Toxicol. 9(5):291-295. (ERL, GB Reprint #159).

Marine unicellular algae were investigated to determine if they differed in their response to herbicides. Eighteen species were tested against the substitute ureas, neburon and diuron, and the triazines, atrazine, and ametryne. Data show that when bioassay analyses are conducted for effects of herbicides on marine unicellular algae, two factors are particularly important: (1) the response in relation to taxonomic position, and (2) the wide range of responses by individual species within a given family. It is necessary, therefore, to use several species from each of several families in algal bioassay studies to obtain realistic data concerning effects of herbicides on algae.

177. Jensen, A.L. 1973. RELATION BETWEEN SIMPLE DYNAMIC POOL AND SURPLUS PRODUCTION MODELS FOR YIELD FROM A FISHERY. J. Fish. Res. Board Can. 30(7):998-1002. (ERL, GB Reprint #157).

Dynamic pool models without self-generating properties are continuous age models, and surplus production models are continuous time models. Self-regenerating dynamic pool models are continuous age-discrete generation models and, also, discrete time-discrete age models. In a steady state, specification of the regulatory function and direct estimation of biomass result in the surplus production model. Estimation of biomass by specifying the functions with respect to age for size of a cohort and individual weight and application of the coefficient of fishing mortality result in the dynamic pool model. A third approach, not applied in fisheries, is to specify the regulatory function and functions with respect to age of cohort size and individual growth in weight. In a steady state, all methods for calculating yield give the same results if the functions specified are realistic. Specification of the functions requires that many assumptions be made. The dynamic pool model may be more accurate than the surplus production model because the regulatory function may be more difficult to determine than the functions with respect to age of cohort size and growth in individual weight.

178. Schoor, W. P. 1973. IN VIVO BINDING OF P,P'-DDE TO HUMAN SERUM PROTEINS. Bull. Environ. Contam. Toxicol. 9(2):70-74. (ERL, GB Reprint #131).

Although it is convenient to estimate chlorinated hydrocarbon pesticide levels in man by determining the amount present in serum, few investigators have questioned possible interactions of these compounds with serum proteins and the resulting consequences. A review is presented of reports emphasizing that direct evidence of serum protein binding under physiological conditions should be obtained.

179. Tagatz, Marlin E. 1973. A LARVAL TARPON, MEGALOPS ATLANTICUS, FROM PENSACOLA, FLORIDA. Copeia 1:140-141. (ERL, GB Reprint #167).

A larval tarpon, *Megalops atlanticus*, was collected in the upper reaches of the East Bay, about 45 km from the Pensacola Inlet, FL, on October 20, 1970. It represents the second and most northern record of a larval tarpon from the Gulf of Mexico and suggests late spawning in the Gulf.

Tagatz, Marlin E., and E. Peter H. Wilkens. 1973. SEASONAL OCCURRENCE OF YOUNG GULF MENHADEN AND OTHER FISHES IN A NORTHWESTERN FLORIDA ESTUARY. U.S. Department of Commerce, NOAA Tech. Rep. NMFS SSRF-672. 14 p.

Gulf menhaden, *Brevoortia patronus*, and other species of fishes were collected by plankton net, seine, and surface trawl from Pensacola Bay, East Bay, and East Bay River from December 1969 to October 1971. Relative abundance, distribution, and relative growth of menhaden are given from the time they enter the estuary as larvae in December to the time they emigrate to the Gulf of Mexico as juveniles in September: 84 species of fishes, representing 46 families, were captured. The number and length range of each species by month are presented; 4 species were not previously recorded from Pensacola estuaries.

Walsh, Gerald E. and Thomas E. Grow. 1973. COMPOSITION OF *THALASSIA TESTUDINUM* and *RUPPIA MARITIMA*. Q. J. Fla. Acad. Sci. 35(2):97-108. (ERL, GB Reprint #126).

This report summarizes an investigation of turtle grass (*Thalassia testudinum*) and widgeon grass (*Ruppia maritima*): seasonal distributions of protein, carbohydrates, trace elements, and energy content of leaves and rhizomes. The potential nutritive value of the seagrasses also is evaluated.

Walsh, Gerald E., Regina Barrett, Gary H. Cook, and Terrence A. Hollister. 1973. EFFECTS OF HERBICIDES ON SEEDLINGS OF THE RED MANGROVE, *RHIZOPHORA MANGLE* L. BioScience 23(6):361-364. (ERL, GB Reprint #143).

Effects of a commercial formulation of 2,4-D and picloram on seedlings of the red mangrove, *Rhizophora mangle* L, are described. In these experiments, a combination of 4.4 kg/ha 2,4-D and 1.6 kg/ha picloram killed all seedlings. Data indicate that relatively low concentrations of auxin-type herbicides inhibit mangrove development. Reclamation of a mangrove forest may be difficult if low residues from previous spraying persist in soil.

1972

Bookhout, C. G., Alfred J. Wilson, Jr., Thomas W. Duke, and Jack I. Lowe. 1972. EFFECTS OF MIREX ON THE LARVAL DEVELOPMENT OF TWO CRABS. Water Air Soil Pollut. 1(1972):165-180. (ERL, GB Reprint #132).

The effects of mirex, a chlorinated hydrocarbon used to kill the imported red ant, Solenopsis saevissima richteri, on the complete larval development of two crabs, Rhithropanopeus harrisii and Menippe mercenaria, are described. The duration of developmental stages of Rhithropanopeus and the total time of development is generally lengthened with an increase in concentration of mirex from 0.01 to 10.0 ppb. There are highly significant differences between survival of larvae in the control and in each concentra- of mirex. In Menippe, there were no pronounced differences in duration of developmental stages with increased concentrations of mirex, but the percentage of extra 6th zoeae was greater as concentrations were increased. There was differential survival of the developmental stages in relation to concentration of mirex, and Menippe larvae were much more sensitive to mirex than Rhithropanopeus larvae, especially in the megalopal stage. Residue analysis indicates that Menippe concentrates mirex more efficiently during development to crab stages than does Rhithropanopeus.

184. Bourquin, Al W., S.K. Alexander, H.K. Speidel, J.E. Mann, and J.F. Fair. 1972. MICROBIAL INTERACTIONS WITH CYCLODIENE PESTICIDES. Dev. Ind. Microbiol. 13:264-276. (ERL, GB Reprint #166).

Studies were conducted on mixed cultures of Pseudomonas sp. and individual isolates in an attempt to support growth on the chlorinated hydrocarbon pesticide, heptachlor, in aqueous systems. Gas chromatographic analysis of the aqueous system demonstrated significant reduction in the concentration of pesticide. Cultures were characterized by moderate growth and significant flow formation. Attempts to correlate growth with reduction in pesticide concentrations were conducted with ^{14}C-labeled simulated technical heptachlor. Isotopic analyses revealed a liberation of $^{14}CO_2$, implicating oxidative dissimilation by the microbial system. Radiochemical assay of cellular constituents showed only low-level, nonspecific incorporation. Additional low-level activity was found in association with glutamate and aspartate in the aqueous phase of the supernatant. Most of the activity remained in original pesticides that were found in close association with the lipid phase of the cellular fraction. Three pesticide metabolites--chlordene, 1-hydroxy-2,3-epoxychlordene, and heptachlor epoxide--in addition to nine unknown by-products were identified. Possible metabolic pathways are discussed. Accumulation of components of simulated technical heptachlor in the lipid-soluble cellular fractions was observed to correlate with degree of chlorination rather than concentration.

185. Butler, Philip A. 1972. DDT IN ESTUARINE MOLLUSKS. BioScience 22(12):690-691. (ERL, GB Reprint #155a).

Samples of mollusks were collected at about 30-day intervals at 183 permanent estuarine sites for periods ranging from 2 to 8 years in 15 coastal states. The occurrence of DDT residues demonstrated its association primarily with agricultural practices. Maximum DDT residues detected (1.0-5.4 ppm) occurred in less than 0.5% of the samples; 62% of all samples contained DDT at levels above 0.005 ppm. In New York and Alabama there was a 100% incidence of DDT residues. In the least polluted areas there was a DDT residue incidence of 15% in Georgia and 11% in Washington.

The data demonstrate that the decline in DDT residues in molluscs has been nearly universal on the Atlantic, Gulf of Mexico, and Pacific coasts, although beginning at different times in different places. In some areas DDT has disappeared from this filter-feeding level of the trophic web within 12 months of the termination of its local use. This suggests that barring further input, DDT will disappear biologically within one or two generations of sensitive estuarine fauna.

186. Butler, P.A., I.E. Andren, G.J. Bonde, A.B. Jernelov, and D.J. Reish. 1972. TEST MONITORING AND INDICATOR ORGANISMS. In: A Guide to Marine Pollution, Edward D. Goldberg, editor. Gordon and Breach, London, pp. 147-159. (ERL, GB Reprint #148).

These guidelines concern the selection of bioassay organisms useful for the detection and evaluation of pollution. Ideally, the selected species or community of different species should reflect the presence or absence of specific pollutants, relative pollution levels, and their periodic fluctuations, and perhaps other factors that contribute to environmental degradation. The species selected should be of value in circumscribed geographic locations, as well as larger water areas. Such an ideal does not exist; therefore, bioassay organisms may be grouped functionally into two general categories as either monitoring or indicator types.

187. Cooley, Nelson R., and James M. Keltner, Jr. 1972. EFFECT OF AROCLOR® 1248, A POLYCHLORINATED BIPHENYL, ON GROWTH OF POPULATIONS OF *TETRAHYMENA PYRIFORMIS* W (CILIATEA: HYMENOSTOMATIDA: HYMENOSTOMATIDAE). ASB Bull. 19(2):61. (ERL, GB Reprint #140).

Populations of *Tetrahymena pyriformis* W were grown in optically matched test tubes at 26°C in broth (2% proteose peptone, 0.1% yeast extract, 0.5% dextrose) that contained 0.1% polyethylene glycol 200 and 10, 100, or 1,000 ppb Aroclor 1248, a polychlorinated biphenyl (PCB). Population density was measured in a spectrophotometer as absorbance at 540 mμ. Growth rate during exponential growth of the population was estimated as the quantity b of the least squares estimate by the line $y = a + bx$ of the exponential portion of the graphed data. In addition, population densities at 96 hr, when control population density is maximal, were compared. Significant reductions in growth rate (18.9%)

and population density (9.6%) ($P < 0.05$, randomized block analysis of variance plus Scheffe procedure) were produced by 1,000 ppb of the PCB, but not by lesser concentrations tested.

188. Cooley, Nelson R., James M. Keltner, Jr., and Jerrold Forester. 1972. MIREX AND AROCLOR® 1254: EFFECT ON AND ACCUMULATION BY TETRAHYMENA PYRIFORMIS STRAIN W. J. Protozool. 19(4):636-638. (ERL, GB Reprint #137).

Effects of 2 toxicants, Mirex and Aroclor 1254, on *Tetrahymena pyriformis* strain W in axenic cultures are investigated. Mirex is a chlorinated hydrocarbon effective against the fire ant, and Aroclor 1254 is a compound structurally related to DDT and used extensively in various industrial processes. Both toxicants reduced growth rates and population densities of *T. pyriformis* grown at 26°C generally in proportion to concentrations of the chemicals, their effects becoming statistically significant ($P < 0.05$) at 0.9 μg/l for Mirex and 1.0 and 10.0 μg/l for Aroclor 1254. Ciliates exposed to the toxicants for 7 days concentrated Mirex 193 X and Aroclor 60 X as compared to the initial concentrations of these compounds. It is suggested that the chief effect of the 2 toxicants on populations of *T. pyriformis* and of similarly responding ciliates in nature would be to reduce the availability of these protozoa as food organisms and nutrient regenerators. The ability of the ciliates to concentrate the tested compounds would permit the toxicants to enter into and to be translocated through aquatic food chains. In this manner the compounds could exert toxic effects at higher trophic levels.

189. Coppage, David L. 1972. ORGANOPHOSPHATE PESTICIDES: SPECIFIC LEVEL OF BRAIN AChE INHIBITION RELATED TO DEATH IN SHEEPSHEAD MINNOWS. Trans. Am. Fish . Soc. 100(3):534-536. (ERL, GB Reprint #113).

Inhibition of brain acetylcholinesterase (AChE) in sheepshead minnows, *Cyprinodon variegatus*, by static exposures to acute doses of Guthion, phorate, and parathion that killed 40 to 60% of the fish in 2, 24, 48, and 72 hr indicates that effect is a function of pesticide concentration and length of exposure. Inhibition to less than 87% of normal activity is necessary to indicate exposure. The greatest inhibition caused by sublethal exposures is not as great as that caused by lethal exposures. Death occurs when AChE activity falls below 17.7% of normal, and levels below this value indicate impending death from exposure even when pesticide concentration and exposure times are unknown. In single test, phosphamidon, Cygon, malathion, EPN, Dursban, DDVP, Diazinon, Dibrom, and methyl parathion caused inhibition to less than 17.7% of normal activity when 40 to 60% of the fish were killed. These data indicate that brain AChE levels, when properly assayed, are dependable indicators of exposure and death.

190. Erickson, Stanton J. 1972. TOXICITY OF COPPER TO *THALASSIOSIRA PSEUDONANA* IN UNENRICHED INSHORE SEAWATER. J. Phycol. 8:318-323.

Toxicity of copper to *T. pseudonana* (formerly *Cyclotella nana*, clone 13-1) was examined in inshore seawater in a 96-hr bioassay. Raw unenriched seawater was filtered through a 22- membrane filter and then pasteurized for 30 min at 60°C. Following this treatment, samples contained 0.68-1.14 µg Cu/1. Copper was added as the chloride in 5 µg increments over the range of 5 to 30 µg/l (about 0.1-0.5 M). Population densities, mean cell volume, and ^{14}C bicarbonate uptake were measured.

Population growth and ^{14}C uptake by *T. pseudonana* displayed inhibition over the entire range of added copper. Growth rate constant (k) of *T. pseudonana* decreased with increasing copper concentration and during the course of growth at each concentration. Correspondingly, mean cell volumes increased with copper concentration and time. Copper toxicity varied in different water samples. The presence of decomposed natural plankton and detritus decreased toxicity. In the absence of enrichment, bacteria had little effect on copper toxicity. Results were influenced by glassware treatment, collection and storage of seawater, and absence of enrichments.

191. Hansen, David J. 1972. DDT AND MALATHION: EFFECT ON SALINITY SELECTION BY MOSQUITOFISH. Trans. Am. Fish. Soc. 101(2):346-350. (ERL, GB Reprint #108).

Behavior of fish is altered after exposure to some pesticides. The response of fish to salinity gradients is important because it affects movement and distribution of species in an estuary. The effect of DDT and malathion on salinity selection by mosquitofish, *Gambusia affinis*, therefore was investigated.

192. Hansen, D.J., E. Matthews, S.L. Nall, and D.P. Dumas. 1972. AVOIDANCE OF PESTICIDES BY UNTRAINED MOSQUITOFISH, *GAMBUSIA AFFINIS*. Bull. Environ. Contam. Toxicol. 8(1):46-51. (ERL, GB Reprint #136).

Some fish possess the capacity to avoid polluted water, but their ability to avoid pesticides has not been extensively studied. In experiments at ERL, GB, sheepshead minnows, *Cyprinodon variegatus*, avoided DDT, endrin, Dursban®, and 2,4-D, but did not avoid malathion or Sevin®. This paper summarizes results of similar experiments conducted to determine if mosquitofish, *Gambusia affinis*, could avoid these pesticides.

193. Heitmuller, Paul T., and Del Wayne R. Nimmo. 1972. A CAGE FOR EXPOSING AQUATIC ANIMALS TO BOTTOM SEDIMENTS. Prog. Fish-Cult. 34(2):120. (ERL, GB Reprint #134).

A holding cage constructed to assess uptake of organic pollutants from estuarine bottom sediments by penaeid shrimp is described. The cage incorporates a two-tier arrangement that enables control animals to be held above the bottom sediment, while experimental animals in the lower compartment are directly exposed to the bottom sediments. Tests show shrimp can survive in the cage for 3 weeks.

194. Lowe, J.I., P.R. Parrish, J.M. Patrick, Jr., and J. Forester. 1972. EFFECTS OF THE POLYCHLORINATED BIPHENYL AROCLOR® 1254 ON THE AMERICAN OYSTER CRASSOSTREA VIRGINICA. Mar. Biol. 17(3):209-214. (ERL, GB Reprint #146).

Young oysters (Crassostrea virginica) were continuously exposed to Aroclor® 1254, a polychlorinated biphenyl (PCB), in flowing, unfiltered seawater. Growth rate (height and inwater weight) was significantly reduced ($\alpha = 0.05$) in oysters exposed to 5 μg/l (ppb) for 24 weeks. Growth rate was not affected in oysters exposed to 1 ppb for 30 weeks. Mortality was not significant in exposed and control groups. In oysters exposed to 5 ppb, greatest PCB residue (whole body) was 425 mg/kg (ppm), 85,000X the concentration in the water, and less than 0.3 ppm was retained after 28 weeks depuration in PCB-free water. In oysters exposed to 1 ppb, greatest residue was 101 ppm, 101,000X the concentration in the water, and less than 0.2 ppm was retained after 12 weeks depuration. Examination of oysters exposed to 5 ppb of this PCB for pathogenesis revealed atrophy of digestive diverticular epithelium and degeneration of vesicular connective tissues concomitant with leukocytic infiltration, but tissue recovery seemed excellent after a 12-week depuration.

195. Nimmo, D.R., and R.R. Blackman. 1972. EFFECTS OF DDT ON CATIONS IN THE HEPATOPANCREAS OF PENAEID SHRIMP. Trans. Am. Fish. Soc. 101(3):547-549. (ERL, GB Reprint #117).

Symptoms of DDT poisoning in penaeid shrimp are described. In acute bioassays (concentrations of 0.15 ppb or more), shrimp showed the nervous impairments--tremors, hyperexcitability, and finally paralysis--which are characteristic of arthropods. In chronic tests, when less DDT was used, shrimp became lethargic, refused food, and finally died, but no nervous disorders were noted. Analyses of shrimp in all tests showed that shrimp accumulated more DDT in the hepatopancreas than in other organs. Data demonstrate that when living shrimp are exposed to DDT, concentrations of some cations in the hepatopancreas became depressed.

196. Parrish, Patrick R., Jack I. Lowe, Alfred J. Wilson, Jr., and James M. Patrick, Jr. 1972. EFFECTS OF AROCLOR® 1254, A PCB, ON OYSTERS, CRASSOSTREA VIRGINICA (BIVALVIA: PROTOBRANCHIA: OSTREIDAE). ASB Bull. 19(2):90. (ERL, GB Reprint #141).

Oysters were continuously exposed to Aroclor 1254, a polychlorinated biphenyl, in flowing, unfiltered seawater. Growth rate (height and in-water weight) was significantly reduced (Student's t-test; variation = 0.05) in oysters exposed to 5.0 µg/l parts per billion (ppb) for 24 weeks, but was not affected in oysters exposed to 1.0 ppb for 30 weeks. Mortality was not significant in any group. In oysters exposed to 5.0 ppb, greatest PCB residue (whole-body) was 425 mg/kg (ppm), a concentration factor of 8.5×10^4, and a trace was retained after 32 weeks depuration in PCB-free water. In oysters exposed to 1.0 ppb, greatest residue was 101 ppm, a 10.1×10^4 concentration factor, and a trace was retained after 12 weeks depuration. Pathological examination of exposed oysters revealed degeneration of vesicular connective tissues concomitant with leukocytic infiltration. Tissue alterations were much greater in oysters exposed to 5.0 ppb, but tissue recovery seemed excellent after 12 weeks depuration.

197. Speidel, H.K., A.W. Bourquin, J.E. Mann, and E.O. Bennett. 1972. MICROBIOLOGICAL REMOVAL OF PESTICIDES FROM AQUEOUS ENVIRONMENTS. Dev. Ind. Microbiol. 13:277-282. (ERL, GB Reprint #166a).

Two mixtures of microorganisms were isolated and formed floc particles in the presence of chlorinated hydrocarbon pesticides. One mixture contained three organisms. The other contained the three found in the first mixture plus one additional organism. The individual organisms were found to vary as to nutritional requirements. Electron microscope studies indicated that the type of floc particle produced depends on the medium used for growth. Exocellular polymers were produced when glucose was used as the carbon source. No polymers were seen with heptachlor as the carbon source. Glucose-grown cells have the ability to remove large amounts of the components of technical heptachlor from pesticide-saturated water.

198. Walsh, Gerald E. 1972. EFFECTS OF HERBICIDES ON PHOTOSYNTHESIS AND GROWTH OF MARINE UNICELLULAR ALGAE. Hyacinth Control J. 10:45-48. (ERL, GB Reprint #130).

Little is known concerning effects of pesticides on marine unicellular algae. This study describes effects of several classes of herbicides upon growth and photosynthesis by four genera of marine unicellular algae.

199. Walsh, Gerald E. 1972. INSECTICIDES, HERBICIDES, AND POLYCHLORINATED BIPHENYLS IN ESTUARIES. J. Wash. Acad. Sci. 62(2):122-139. (ERL, GB Reprint #139).

Pesticides are present in estuaries throughout the world, and it is probable that they will remain there for an indefinite period of time. Production rate of chemical pesticides has increased by about 16% each year since 1964. About 390 chemicals are used in pest control. They reach estuaries through runoff from land, discharge of municipal and industrial wastes, direct application to marshes, aerial drift, and accidental discharge. Residues of pesticides are found in water, sediment, and at all levels of estuarine trophic pyramids, but there is still uncertainty as to what these residues mean in terms of toxicity, reproduction, and other factors relating to estuarine organisms in the field. Data from both laboratory and field studies suggest a few beneficial and many harmful effects of pesticides in estuaries. In this presentation, insecticides, herbicides, and polychlorinated biphenyl compounds are discussed in relation to survival, photosynthesis, behavior, metamorphosis, resistance, and chemical changes in tissues of estuarine organisms.

1971

200. Coppage, David L. 1971. CHARACTERIZATION OF FISH BRAIN ACETYLCHOLINESTERASE WITH AN AUTOMATED pH STAT FOR INHIBITION STUDIES. Bull. Environ. Contam. Toxicol. 6(4):304-310. (ERL, GB Reprint #125).

    This report concerns characterization of brain AChE of sheepshead minnows, *Cyprinodon variegatus*, by an automated pH stat for inhibition studies. The function of enzyme and choline ester concentration, the action of enzyme on specific choline esters, and the effects of pH and temperature on AChE activity were investigated to determine suitable assay conditions for brain AChE. Also, the effects of several inhibitors were studied *in vitro* and compared with toxicity. A method for *in vivo* inhibition studies is proposed.

201. Duke, Thomas W., and Alfred J. Wilson, Jr. 1971. CHLORINATED HYDROCARBONS IN LIVERS OF FISHES FROM THE NORTHEASTERN PACIFIC OCEAN. Pest. Monit. J. 5(2):228-232. (ERL, GB Reprint #127).

    Occurrences of pesticides in seafood, such as Jack mackerel from California, prompted the Bureau of Commercial Fisheries (BCF), now the National Marine Fisheries Service (NMFS), to conduct a preliminary survey of the pesticide content of some coastal fish from the Northeastern Pacific. The purpose of the survey was to determine if these fish had recently accumulated or were in the process of accumulating commonly used chlorinated hydrocarbon pesticides and to point out some specific problem areas: a comprehensive monitoring program could be established later on the basis of these and other results. Investigators at the Environmental Research Laboratory, Gulf Breeze, coordinated the survey as planned by BCF and analyzed the samples. Samples were collected and prepared for analysis by personnel from NMFS Laboratories at La Jolla, CA, Seattle, WA, and Auke Bay, AK.

This report presents the levels of pesticides found in the fish livers.

202. Hansen, David J. 1971. EVALUATION OF STOCKING CUTTHROAT TROUT, *SALMO CLARKI*, IN MUNSEL LAKE, OREGON. Trans. Am. Fish. Soc. 100(1):55-60. (ERL, GB Reprint #103).

Natural mortality, emigration, and yield to anglers were assessed in 1962 for three releases of cutthroat trout (*Salmo clarki*) in Munsel Lake, Oregon. Stocked fish were caught emigrating from March 30, the start of trapping, to July 3. Natural mortality, 16 to 75%, was the dominant factor determining the number of fish available to anglers, and this mortality was greatest when anglers could not fish immediately after stocking. Yield of trout to anglers, estimated by creel census, indicated that after release fish were removed rapidly from the lake.

Catch by anglers could be increased and catch per unit effort stabilized by liberating trout just before the fishing season and once or twice in the summer. This policy could reduce losses of fish from natural mortality and emigrations.

203. Hansen, D.J., P.R. Parrish, J.I. Lowe, A.J. Wilson, Jr., and P.D. Wilson. 1971. CHRONIC TOXICITY, UPTAKE, AND RETENTION OF AROCLOR® 1254 IN TWO ESTUARINE FISHES. Bull. Environ. Contam. Toxicol. 6(2):113-119. (ERL, GB Reprint #120).

Chronic toxicity tests are conducted to determine effects of low levels of Aroclor 1254 on pinfish (*Lagodon rhomboides*) and spot (*Leiostomus xanthurus*). Results suggest that chronic exposure to Aroclor 1254 increased susceptibility of test pinfish and spot to disease, and also appeared to be toxic to these fish. This PCB is rapidly stored by pinfish and spot, and persists in tissues for approximately three months. These findings emphasize the need for further study on the effect of chronic exposure of aquatic organisms to polychlorinated biphenyls.

204. Hochberg, F.G., and John A. Couch. 1971. BIOLOGY OF CEPHALOPODS. In: Scientists-in-the-Sea, J.W. Miller, J.G. VanDerwalker, editors. U.S. Department of the Interior, Washington, DC, pp. VI-221-VI-228. (ERL, GB Reprint #118).

Few studies of cephalopod mollusks have been made *in situ*. Mission 8-50, TEKTITE II, made possible a three-week study (July-August) of octopods and squids in Greater Lameshur Bay, St. John, U.S. Virgin Islands. A cross sectional study revealed the presence of at least three species of Octopus: *O. briareus*; *O. macropus*; and *O. vulgaris*. Observations on activity periods, territoriality, feeding, and general behavior of these octopods were made. Three different genera and species of squid were observed: *Sepiotheuthis sepioidea*; *Pickfordiateuthis pulchella*;

and *Loligo plei*. Observations on schooling behavior, space requirements, mating, and feeding are presented on these squid.

205. Nimmo, D.R., R. Blackman, A.J. Wilson, Jr., and J. Forester. 1971. TOXICITY AND DISTRIBUTION OF AROCLOR® 1254 IN THE PINK SHRIMP *PENAEUS DUORARUM*. Mar. Biol. 11(3):191-197. (ERL, GB Reprint #128).

The polychlorinated biphenyl Aroclor® 1254 was released in an accidental leakage of heat-exchange fluid from an industrial plant, into the Escambia River, near Pensacola, FL. This material was carried downstream, and is now found in the fauna of Escambia Bay and its contiguous waters, prime nursery areas for fishes and invertebrates such as penaeid shrimp. The significance of pollution by this chemical was assessed by establishing toxicity levels, determining routes of entry, and investigating its movement and distribution in various tissues of shrimp under controlled conditions in the laboratory. Aroclor 1254 added to the water was toxic to the juvenile pink shrimp *Penaeus duorarum* at a concentration of 1.0 ppb within 15 days, but was less toxic to adult pink shrimp. Shrimp obtained the contaminant from water and food and concentrated it to 510.0 ppm in the hepatopancreas. Aroclor 1254 residue data from shrimp collected in the estuary are included in the study.

206. Nimmo, D.R., P.D. Wilson, R.R. Blackman, and A.J. Wilson, Jr. 1971. POLYCHLORINATED BIPHENYL ABSORBED FROM SEDIMENTS BY FIDDLER CRABS AND PINK SHRIMP. Nature 231(5297):50-52. (ERL, GB Reprint #111).

Fiddler crabs and shrimp exposed to sediments contaminated by Aroclor® 1254, a polychlorinated biphenyl (PCB), are shown to accumulate the PCB in their tissues by ingesting contaminated particles or by absorbing the leached chemical from water. It is demonstrated experimentally that Aroclor 1254 can enter the estuarine food chain from sediments.

207. Sprague, Victor, and John A. Couch. 1971. AN ANNOTATED LIST OF PROTOZOAN PARASITES, HYPERPARASITES, AND COMMENSALS OF DECAPOD CRUSTACEA. J. Protozool. 18(3):526-537. (ERL, GB Reprint #106).

This taxonomic paper presents a complete list of protozoa known to be associated with decapods and covers a few problems in classification and nomenclature. Subjects of host and site of infection, locality, and pathogenecity also are included.

208. Tagatz, Marlin E. 1971. OSMOREGULATORY ABILITY OF BLUE CRABS IN DIFFERENT TEMPERATURE-SALINITY COMBINATIONS. Chesapeake Sci. 12(1):14-17.

Adult male and immature, mature, and ovigerous female blue crabs, *Callinectes sapidus*, prefer different portions of estuaries. Total osmotic concentrations of blood samples from crabs held in 5, 50, or 100% seawater (salinity 34 °/oo) at 10, 20, or 30°C indicated that some differences in osmoregulatory capabilities were related to differences in distribution. Ovigerous females did not regulate as well as mature females or adult males at 5 or 50% seawater, at all temperatures. In 50 or 100% seawater, osmotic concentrations of immature females generally were less than those of mature females. At almost all temperature-salinity combinations, however, differences in the osmoregulatory ability of adult males and mature females were not significant. The blue crab showed good hyperosmotic regulation in 5 and 50% seawater but regulated its blood hyposmotically in 100% seawater.

209. Tagatz, Marlin E., and Ann Bowman Hall. 1971. ANNOTATED BIBLIOGRAPHY ON THE FISHING INDUSTRY AND BIOLOGY OF THE BLUE CRAB, CALLINECTES SAPIDUS. National Marine Fisheries Service, NOAA Tech. Rep. NMFS SSRF-640:1-94.

This bibliography provides scientific and industrial investigators an updated and comprehensive list of references to the literature on the blue crab, Callinectes sapidus. Authors are listed alphabetically, and each author's work is listed chronologically by year of publication.

210. Walsh, Gerald E. 1971. ENERGY BUDGETS OF FOUR PONDS IN NORTHWESTERN FLORIDA. Ecology, 52(2):298-304. (ERL, GB Reprint #105).

The annual energy budgets of four small ponds in northwestern Florida were calculated from the amounts of 1) solar radiation, 2) atmospheric long-wave radiation, 3) back radiation, 4) evaporative energy, 5) conducted energy, and 6) sensible heat that was lost from the water. Long-wave radiation constituted between 62.1 and 63.9% of the total incoming radiative energy and 80.8 to 85.0% of the total energy loss. Evaporative loss was between 14.6 and 18.3% of the total. Between 370,498 and 631,970 kcal $m^{-2}yr^{-1}$ (37,050-63,197 cal $cm^{-2}yr^{-1}$) were stored. Atmospheric radiation counteracts a portion of the radiative loss from water, thus reducing loss of stored solar energy.

211. Walsh, Gerald, and Ralph L. Bowers. 1971. A REVIEW OF HAWAIIAN ZOANTHIDS WITH DESCRIPTIONS OF THREE NEW SPECIES. Zool. J. Linn. Soc. 50(2):161-180. (ERL, GB Reprint #92).

This paper describes zoanthids collected from coral reefs and shores of the Hawaiian Islands between June 1965 and June 1967. Isaurus elongatus Verrill (1928) and Palythoa tuberculosa Esper (1971) are redescribed and Zoanthus vestitus Verrill (1928) is reclassified as Palythoa vestitus. Zoanthus confertus Verrill (1928) and Z. nitidus Verrill (1928) are combined under the new species name Zoanthus pacificus. New species described are P. psammophilia, P. toxica, and Z. kealakekuaensis. A list of zoanthid species from the southwestern Pacific Ocean is given.

212. Walsh, Gerald E., and Thomas E. Grow. 1971. DEPRESSION OF CARBOHYDRATE IN MARINE ALGAE BY UREA HERBICIDES. Weed Science. 19(5):568-570. (ERL, GB Reprint #121).

Representative species of six genera of marine unicellular algae (*Chlorococcum* sp., *Dicrateria inornata* Parke, *Dunaliella tertiolecta* Butcher, *Nannochloris* sp., *Isochrysis galbana* Parke, and *Monochrysis lutheri* Droop) were treated in unialgal culture with 3-(3,4-dichlorophenyl)-1,1-dimethylurea (diuron), 1-butyl-3-(3,4-dichlorophenyl)-1-methylurea (neburon), 3-(p-chlorophenyl)-1,1-dimethylurea (monuron), and 1,1-dimethyl-3-phenylurea (fenuron). Tests were conducted at salinities of 5, 10, 20, and 30 °/oo. The herbicides depressed concentration of carbohydrate in all species. *Dunaliella tertiolecta* was most resistant; its carbohydrate content deceased 9.2% at 5 °/oo salinity and 17.9% at 30 °/oo. *Chlorococcum* was most susceptible; its carbohydrate content decreased 49.1% at 5 °/oo and 65.6% at 30 °/oo salinity.

213. Walsh, Gerald E., Charles W. Miller, and P.T. Heitmuller. 1971. UPTAKE AND EFFECTS OF DICHLOBENIL IN A SMALL POND. Bull. Environ. Contam. Toxicol. 6(3):279-288, (ERL, GB Reprint #123).

The herbicide 2, 6-dichlorobenzonitrile (dichlobenil, Casoron®) is used throughout the United States for control of submerged aquatic weeds. It is not effective against filamentous algae and has little effect upon plankton and fish except at high concentrations. In this study, a small pond is treated with dichlobenil in order to measure uptake by organisms and effects of treatment upon oxygen production, plankton dynamics, and water chemistry.

Presentations

Papers listed below were published in conference and workshop proceedings under authorship of researchers employed at the Gulf Breeze Laboratory and its field station, or supported by EPA grants, contracts, or interagency agreements. Selected articles are available in limited quantities at the ERL Library, Gulf Breeze, FL 32561.

1978

214. Block, Ronald M., Dennis T. Burton, Steven R. Gullans, and Leonard B. Richardson. 1978. RESPIRATORY AND OSMOREGULATORY RESPONSES OF WHITE PERCH (*MORONE AMERICANA*) EXPOSED TO CHLORINE AND OZONE IN ESTUARINE WATERS. In: Water Chlorination: Environmental Impact and Health Effects, Vol. 2, Robert L. Jolley, Hend Gorchev, and D. Heyward Hamilton, Jr., editors. Ann Arbor Sci. Publ. Inc., Ann Arbor, MI. pp. 351-360.

    Investigations of the acute toxicity of chlorine and ozone to an euryhaline teleost are described. Ozone appears to produce a more rapid breakdown of physiological processes of the white perch, *Morone americana*, than chlorine. Both oxidants produce a deleterious effect on gill tissue, and ultimately affect gill functions. Their mode of action appears to be the same in that osmoregulatory and respiratory mechanisms are affected in the same manner.

215. Borthwick, Patrick W., and Steven C. Schimmel. 1978. TOXICITY OF PENTACHLOROPHENOL AND RELATED COMPOUNDS TO EARLY LIFE STAGES OF SELECTED ESTUARINE ANIMALS. In: Pentachlorophenol: Chemistry, Pharmacology, and Environmental Toxicology, K. Ranga Rao, editor. Plenum Press, New York, NY. pp. 141-146. (ERL, GB Reprint #343).

    Newly hatched individuals of four estuarine species were exposed to pentachlorophenol (PCP), sodium pentachlorophenate (Na-PCP), or Dowicide® G (79% Na-PCP), in static toxicity tests.

    The 96-hr LC50 values for sheepshead minnow (*Cyprinodon variegatus*) fry exposed to PCP at ages 1-day, 2-week, 4-week, and 6-week were 329, 392, 240, and 223 µg/l, respectively. The 96-hr LC50 value for 2-week-old fry exposed to Dowicide® G was 516 µg/l. The larvae (48-hr post hatch) of pinfish, *Lagodon rhomboides*, were particularly sensitive to Na-PCP (96-hr LC50: 38 µg/l) and Dowicide® G (96-hr LC50:66 µg/l). For 24-hr-old grass shrimp (*Palaemonetes pugio*) larvae exposed to NA-PCP the

96-hr LC50 was 649 µg/l. Na-PCP caused abnormal development of eastern oyster (Crassostrea virginica) embryos; the 48-hr EC50 was 40 µg/l.

216. Bourquin, Al W., and David T. Gibson. 1978. MICROBIAL DEGRADATION OF HALOGENATED HYDROCARBONS. In: Water Chlorination, Environmental Impact and Health Effects, Vol. 2, Robert L. Jolley, Hend Gorchev, and D. Heyward Hamilton, Jr., editors. Ann Arbor Sci. Publ. Inc., Ann Arbor, MI. pp. 253-258. (ERL, GB Reprint #361).

Biochemical and soil microbiology studies indicate that numerous mechanisms exist for the dehalogenation of both aliphatic and aromatic hydrocarbons. Tests described in this paper demonstrate that enzymatic systems are capable of dehalogenation. The report does not answer the question of the biodegradability of halogenated hydrocarbons, but illustrates the need for more information in order to identify compounds likely to undergo enzymatic cleavage of the carbon-halogen bond.

217. Brannon, Anita C., and Philip J. Conklin. 1978. EFFECT OF SODIUM PENTACHLOROPHENATE ON EXOSKELETAL CALCIUM IN THE GRASS SHRIMP, PALAEMONETES PUGIO. In: Pentachlorophenol: Chemistry, Pharmacology, and Environmental Toxicology, K. Ranga Rao, editor. Plenum Press, New York, NY. pp. 205-211.

Exposure of the grass shrimp, Palaemonetes pugio, to media containing sodium pentachlorophenate (Na-PCP) led to an apparent increase in the dry weight of exuvia as well as an increase in the total quantity of calcium. The actual calcium concentration (µg Ca/mg dry exoskeleton) in exuvia did not vary significantly in relation to Na-PCP exposure. Whether the observed changes in exuvia from shrimp exposed to Na-PCP are due to a decrease in the resorption of the old exoskeleton preceding ecdysis remains to be clarified.

218. Cantelmo, Angela C., Philip J. Conklin, Ferris R. Fox, and K. Ranga Rao. 1978. EFFECTS OF SODIUM PENTACHLOROPHENATE AND 2,4-DINITROPHENOL ON RESPIRATION IN CRUSTACEANS. In: Pentachlorophenol: Chemistry, Pharmacology, and Environmental Toxicology, K. Ranga Rao, editor. Plenum Press, New York, NY. pp. 251-263.

The oxygen consumption of the grass shrimp, Palaemonetes pugio, was determined at different stages of the molt cycle. At each stage of the molt cycle, the oxygen consumption varied in relation to periods of activity. In order to minimize the errors in establishing basal (control) rates of oxygen consumption, measurements were made over extended periods (18 to 24 hr). In contrast to the previous reports of progressive increases in oxygen consumption during proecdysial stages in other crustaceans, we noted significant increases in oxygen consumption just prior to and during the actual shedding of exoskeleton (ecdysis) in grass shrimp. The effects of sodium pentachlorophenate (Na-PCP) on oxygen consumption varied depending on the stage of the molt cycle, concentration of Na-PCP, and extent of pre-exposure of shrimp to Na-PCP.

The effects of Na-PCP and DNP on tissue respiration *in vitro* were studied with the blue crab, *Callinectes sapidus*. At concentrations of 1 x 10^{-6} M and 5 x 10^{-5} M, these compounds did not alter the oxygen consumption of the muscle, gill, and hepatopancreas. At a concentration of 5 x 10^{-3} M, both Na-PCP and DNP caused an inhibition of oxygen consumption of isolated tissues.

219. Cantelmo, Frank R., and K. Ranga Rao. 1978. EFFECTS OF PENTACHLOROPHENOL ON THE MEIOBENTHIC NEMATODES IN AN EXPERIMENTAL SYSTEM. In: Pentachlorophenol: Chemistry, Pharmacology, and Environmental Toxicology, K. Ranga Rao, editor. Plenum Press, New York, NY. pp. 165-174.

Aquaria containing clean sand received a continuous supply of seawater from Santa Rosa Sound, Florida, mixed with known quantities of PCP for 9 weeks (May 10 - July 12, 1976) for the first experiment and Dowicide® G-ST for 13 weeks (December 27, 1976 - March 28, 1977) for the second experiment. The measured concentrations of PCP in the former experiment were 7, 76, and 622 μg/l while the concentrations of 1.8, 15.8, and 161 μg/l were used in the latter experiment. At the end of each experiment the meiofauna established in the control and experimental aquaria were examined. Nematodes were the dominant group and averaged 83% of all the meiofauna encountered. Concentrations of 1.8, 7, and 15.8 μg PCP/l did not affect the biomass and density of nematodes. Marked changes in nematode species composition and shifts in nematode feeding types were noticed in the aquaria exposed to 161 and 622 μg PCP/l. Nematodes classified as epistrate feeders were most abundant in the control aquaria and those exposed to 1.8, 7, 15.8, and 76 μg PCP/l. Deposit feeders were relatively abundant among the nematodes in aquaria exposed to 161 and 622 μg PCP/l. The alterations in nematodes observed in this investigation appeared to be due to the variations in macrobenthic fauna and food (algae) supply caused by the biocidal effects of PCP and also due to the toxic effects of PCP on meiofauna.

220. Carpenter, James H., and Donald L. Macalady. 1978. CHEMISTRY OF HALOGENS IN SEAWATER. In: Water Chlorination: Environmental Impact and Health Effects, Vol. 1, Robert L. Jolley, editor. Ann Arbor Sci. Publ. Inc., Ann Arbor, MI. pp. 161-179.

There has not been sufficient research to provide a satisfactory understanding of the reactions that occur when +1 oxidation state chlorine is added to seawater. However, present information suggests that the bromide ion is oxidized and, perhaps, disproportionates to several oxidation states. Formation of brominated or mixed brominated-chlorinated organic compounds can be expected, but the extent and speciation of such reactions remain to be determined.

221. Carpenter, James H., and Carroll A. Smith. 1978. REACTIONS IN CHLORINATED SEAWATER. In: Water Chlorination: Environmental Impact and Health Impacts,

Vol. 2, Robert L. Jolley, Hend Gorchev, and D. Heyward Hamilton, Jr., editors. Ann Arbor Sci. Publ. Inc., Ann Arbor, MI. pp. 195-207.

Observations of the conditions for the accurate measurement of residual oxidants in chlorinated seawater are described. Results of the investigation suggest that chlorination of seawater may produce toxicity and growth reduction through the indirect mechanism of modifying the copper complexing capacity of the treated water.

222. Conklin, Philip J., and K. Ranga Rao. 1978. TOXICITY OF SODIUM PENTACHLOROPHENATE TO THE GRASS SHRIMP, *PALAEMONETES PUGIO*, IN RELATION TO THE MOLT CYCLE. In: Pentachlorophenol: Chemistry, Pharmacology, and Environmental Toxicology, K. Ranga Rao, editor. Plenum Press, New York, NY. pp. 181-192.

The toxicity of sodium pentachlorophenate (Na-PCP) to the grass shrimp, *Palaemonetes pugio*, was evaluated at different stages of the molt cycle. In 96-hr bioassays, the shrimp in later stages of the proecdysial period exhibited a greater sensitivity to Na-PCP than that exhibited by shrimp in the intermolt and early proecdysial stages of the molt cycle. The shrimp in later proecdysial stages generally molted during the 96-hr test period and died shortly after. The 96-hr LC50 value obtained for these shrimp (0.436 ppm) is the lowest of all the LC50 values reported previously for adult crustaceans and is comparable to those for fish and larval crustaceans. Studies with ^{14}C-PCP indicate that an abrupt increase in the uptake of PCP during the period shortly after ecdysis may cause increased mortalities during this period.

223. Davis, William P., and William F. McIlhenny. 1978. MARINE WORKSHOP SUMMARY. In: Water Chlorination: Environmental Impact and Health Effects, Vol. 2, Robert L. Jolley, Hend Gorchev, and D. Heyward Hamilton, Jr., editors. Ann Arbor Sci. Publ. Inc., Ann Arbor, MI. pp. 859-862.

Proceedings of the Marine Workshop held during the second conference on the Environmental Impact of Water Chlorination, October 31-November 4, 1977, in Gatlinburg, TN, under sponsorship of the Oak Ridge National Laboratory, U.S. Environmental Protection Agency and the Department of Energy. Papers and discussion describe research considerations, problems, and viewpoints regarding chlorination impacts in marine and freshwater ecosystems.

224. Davis, William P., and Douglas P. Middaugh. 1978. A REVISED REVIEW OF THE IMPACT OF CHLORINATION PROCESSES UPON MARINE ECOSYSTEMS. In: Water Chlorination: Environmental Impact and Health Effects, Vol. 1, Robert L. Jolley, editor. Ann Arbor Sci. Publ. Inc., Ann Arbor, MI. pp. 283-310.

This paper presents a theoretical degradation model of chlorine added to marine waters. Additionally, it summarizes literature reporting laboratory or ecological effects of chlorination. The revisions attempt to incorporate pertinent literature through 1977.

225. Doughtie, Daniel G., and K. Ranga Rao. 1978. ULTRASTRUCTURAL CHANGES INDUCED BY SODIUM PENTACHLOROPHENATE IN THE GRASS SHRIMP, *PALAEMONETES PUGIO*, IN

RELATION TO THE MOLT CYCLE. In: Pentachlorophenol: Chemistry, Pharmacology, and Environmental Toxicology, K. Ranga Rao, editor. Plenum Press, New York. pp. 213-250.

> Intermolt (stage C) grass shrimp were exposed to 1.0 ppm Na-PCP for the duration of a molt cycle. Gills, hepatopancreas, midgut (portion of the digestive tract surrounded by hepatopancreas), and hindgut (portion of the digestive tract in the abdomen) from control and experimental shrimp at known stages of the molt cycle were examined at the ultrastructural level. Although signs of pathology were evident in late proecdysial shrimp, extensive pathological changes were not observed until after ecdysis. The extent of pathological changes varied with the tissue examined and the interval between ecdysis and the time of fixation for electron microscopy.

226. Erickson, Stanton J., and Anne E. Freeman. 1978. TOXICITY SCREENING OF FIFTEEN CHLORINATED AND BROMINATED COMPOUNDS USING FOUR SPECIES OF MARINE PHYTOPLANKTON. In: Water Chlorination: Environmental Impact and Health Effects, Vol. 2, Robert L. Jolley, Hend Gorchev, D. Heyward Hamilton, Jr., editors. Ann Arbor Sci. Publ. Inc., Ann Arbor, MI. pp. 307-310. (ERL, GB Reprint #359).

> No distinction has been made in the scientific literature between the effects of the oxidative stages of chlorination and the effects of halogenated compounds formed as by-products. Screening tests of compounds, which are known by-products of chlorination, were performed on four species of marine phytoplankton. Eight concentrations of the test compound were studied over a seven-day period. Different responses such as stimulatory, inhibitory, or no effect were determined on algal cell division. These tests identified organism sensitivity to the test compounds and established the working range for more comprehensive studies.

227. Fox, Ferris R., and K. Ranga Rao. 1978. EFFECTS OF SODIUM PENTACHLOROPHENATE AND 2,4-DINITROPHENOL ON HEPATOPANCREATIC ENZYMES IN THE BLUE CRAB, *CALLINECTES SAPIDUS*. In: Pentachlorophenol: Chemistry, Pharmacology, and Environmental Toxicology, K. Ranga Rao, editor. Plenum Press, New York. pp. 265-275.

> In view of the lack of information on the mechanism of PCP-induced toxicity in crustaceans, this investigation was undertaken to evaluate the effects of sodium pentachlorophenate (Na-PCP) *in vivo* and *in vitro* on certain hepatopancreatic enzymes in the blue crab, *Callinectes sapidus*. Fumarase, malate dehydrogenase, and succinate dehydrogenase were inhibited by Na-PCP and DNP *in vivo*, whereas isocitrate dehydrogenase was stimulated. Of those tested, lactic dehydrogenase was the least affected cytoplasmic (soluble) enzyme *in vivo* while pyruvate kinase and glucose-6-phosphate dehydrogenase were inhibited at least 50% by Na-PCP. Glutamate-pyruvate

transaminase was also inhibited. Na-PCP and DNP had an inhibitory effect on the various enzymes tested in vitro at concentrations of 10^{-4} M or higher. In general, the mitochondrial enzymes were more susceptible than cytoplasmic enzymes to DNP and Na-PCP. The calcium activated ATPase from the microsomal fraction of the crab hepatopancreas was inhibited by Na-PCP and DNP in vitro and in vivo. Na-PCP was more potent than DNP in inhibiting the ATPase activity. The effects of PCP on the blue crab enzymes are compared to the results of previous investigations on other organisms.

228. Goodman, Larry R., David J. Hansen, John A. Couch, and Jerrold Forester. 1978. EFFECTS OF HEPTACHLOR AND TOXAPHENE ON LABORATORY-REARED EMBRYOS AND FRY OF THE SHEEPSHEAD MINNOW. Proc. 30th Annu. Conf. Southeast. Assoc. Game Fish Comm., October 24-27, 1976, Jackson, MS, Wilmer Rogers, editor. pp. 192-202. (ERL, GB Reprint #297).

Flow-through seawater bioassays of 28-days duration were conducted with the organo-chlorine pesticides heptachlor and toxaphene to determine their toxicity to and bioconcentration by embryos and fry of the sheepshead minnow (Cyprinodon variegatus). At technical heptachlor measured concentrations of 4.3, 3.5, 2.2, 2.0, and 1.2 µg/l (ppb), test animal survival was 1, 5, 61, 79, and 88%, respectively. At toxaphene measured concentrations of 2.5, 1.1, 0.6, 0.3, and 0.2 µg/l, test animal survival was 10, 85, 79, 88, and 80%, respectively. Average standard length of fry continuously exposed from fertilization to heptachlor concentrations of 4.3 and 3.5 µg/l was significantly reduced ($\alpha = 0.01$). Concentration factors (concentration in fish/measured concentration in water) for heptachlor averaged 3,600 and for transchlordane averaged 8,600. Heptachlor epoxide and cis-chlordane were also present in the fish. Concentration factors for toxaphene in fry averaged 9,800.

229. Helz, George R., Richard Sugam, and Rong Y. Hsu. 1978. CHLORINE DEGRADATION AND HALOCARBON PRODUCTION IN ESTUARINE WATERS. In: Water Chlorination: Environmental Impact and Health Effects, Vol. 2, Robert L. Jolley, Hend Gorchev, and D. Heyward Hamilton, Jr., editors. Ann Arbor Sci. Publ. Inc., Ann Arbor, MI. pp. 209-222.

Questions related to the chemical processes that create chlorine demand and control chlorine decay in estuarine waters are discussed. Authors conclude that analytical methods must be developed or improved in order to quantitatively account for all chlorine that is added to a water body.

230. Rao, K. Ranga, Philip J. Conklin, and Anita C. Brannon. 1978. INHIBITION OF LIMB REGENERATION IN THE GRASS SHRIMP, PALAEMONETES PUGIO, BY SODIUM PENTACHLOROPHENATE. In: Pentachlorophenol: Chemistry, Pharmacology, and Environmental Toxicology, K. Rango Rao, editor. Plenum Publ. Corp., New York, pp. 193-203.

The initiation and progress of regeneration following the removal of the left fifth pereiopod were studied in the grass shrimp, Palaemonetes pugio. The regeneration patterns of 400 shrimp subjected to various treatments revealed that sodium pentachlorophenate (Na-PCP) affects the initiation and progress of limb regeneration. Depending on the concentration used, Na-PCP caused either a complete inhibition of regeneration, a delay of initiation of limb bud development, or a reduction of limb bud growth without altering the intermolt duration. The inhibitory effects of Na-PCP were more pronounced on the initial phases of limb regeneration (involving wound healing, cell division and dedifferentiation) than on the later phases of regeneration (involving further differentiation and cellular enlargement). Crustacean limb regeneration can be used as a sensitive bioassay for studying the effects of chemical pollutants.

231. Roberts, Morris H., Jr. 1978. EFFECTS OF CHLORINATED SEAWATER ON DECAPOD CRUSTACEANS. In: Water Chlorination: Environmental Impact and Health Effects, Vol. 2, Robert L. Jolley, Hend Gorchev, and D. Heyward Hamilton, Jr., editors. Ann Arbor Sci. Publ. Inc., Ann Arbor, MI. pp. 329-334.

This study assesses the acute and subacute effects of chlorinated seawater on Panopeus herbstii and Pagurus langicarpus eggs and larvae. Exposure of eggs and larvae of the two crab species to reasonably uniform concentrations of chlorine-induced oxidants in a continuous-flow system showed a greater tolerance of eggs compared to zoeae. A seasonal change in the acute toxicity for Panopeus herbstii zoeae was apparent: larvae produced late in the normal breeding season were more sensitive than those produced during the remainder of the breeding season.

232. Rubinstein, Norman I. 1978. EFFECT OF SODIUM PENTACHLOROPHENATE ON THE FEEDING ACTIVITY OF THE LUGWORM, ARENICOLA CRISTATA STIMPSON. In: Pentachlorophenol: Chemistry, Pharmacology, and Environmental Toxicology, K. Ranga Rao, editor. Plenum Publ. Corp., New York. pp. 175-180.

A benthic bioassay utilizing time-lapse photography was used to measure the effect of four concentrations of Na-PCP (45, 80, 156, and 276 μg/l) on the feeding activity of Arenicola cristata. There was no marked effect on feeding activity at 45 μg/l. Na-PCP significantly affected feeding activity at concentrations of 80, 156, and 276 μg/l. As the lugworm feeds, it mixes organic material and oxygenated water into the substrate. Inhibition of this activity could affect benthic community trophic structure and substrate-water column dynamics.

233. Schimmel, Steven C., James M. Patrick, Jr., and Linda F. Faas. 1978. EFFECTS OF SODIUM PENTACHLOROPHENATE ON SEVERAL ESTUARINE ANIMALS: TOXICITY, UPTAKE, AND DEPURATION. In: Pentachlorophenol: Chemistry, Pharmacology, and Environmental Toxicology, K. Ranga Rao, editor. Plenum Publ. Corp., New York. pp. 147-155. (ERL, GB Reprint #336).

Several estuarine animals were exposed to sodium pentachlorophenate (Na-PCP) in flow-through toxicity tests. The following are test animals and their 96-hr LC50 values: grass shrimp (*Palaemonetes pugio*), >515 μg/l; brown shrimp (*Penaeus aztecus*), >195 μg/l; longnose killifish (*Fundulus similis*), >306 μg/l; pinfish (*Lagodon rhomboides*), 53.2 μg/l; and striped mullet (*Mugil cephalus*), 112 μg/l. The 192-hr EC50 (effect measured was shell deposition) for the eastern oyster (*Crassostrea virginica*) was 76.5 μg/l. Eastern oysters exposed to Na-PCP concentrations of 25.0 and 2.5 μg/l accumulated the chemical in their tissues an average of 41 and 78 times, respectively. After Na-PCP delivery was discontinued, however, the oysters purged themselves of the pesticide within four days.

234. Scott, Geoffrey I., and Douglas P. Middaugh. 1978. SEASONAL CHRONIC TOXICITY OF CHLORINATION TO THE AMERICAN OYSTER, *CRASSOSTREA VIRGINICA* (G). In: Water Chlorination: Environmental Impact and Health Effects, Vol. 2, Robert L. Jolley, Hend Gorchev, and D. Heyward Hamilton, Jr., editors. Ann Arbor Sci. Publ. Inc., Ann Arbor, MI. pp. 311-327. (ERL, GB Reprint #360).

Lethal and sublethal effects of chlorination to adult oysters (*Crassostrea virginica*) were observed during chronic exposures on a seasonal basis. Results show that chronic exposures of oysters to chlorine-produced oxidants (CPO's) can produce mortality at high concentrations and severe sublethal effects at lower levels. Toxicity varies from season to season and is related to seasonal changes in measured CPO concentrations, temperature, and the physiological condition of the oyster. Sublethal effects appear to be related to reductions in feeding and increased avoidance of CPO's. This results in reduced tissue production, causing severe reductions in the size of gonadal tissues and increased dependence in glycogen reserves during exposures to CPO's.

235. Tagatz, M.E., J.M. Ivey, and M. Tobia. 1978. EFFECTS OF DOWICIDE® G-ST ON DEVELOPMENT OF EXPERIMENTAL ESTUARINE MACRO-BENTHIC COMMUNITIES. In: Pentachlorophenol: Chemistry, Pharmacology, and Environmental Toxicology, K. Ranga Rao, editor. Plenum Publ. Corp., New York. pp. 157-163. (ERL, GB Reprint #352).

Aquaria containing clean sand received a continuous supply of flowing seawater from Santa Rosa Sound, FL, mixed with known quantities of Dowicide® G-ST (79% sodium pentachlorophenate) for 13 weeks. The measured concentrations of pentachlorophenol (PCP) in the aquaria were 1.8, 15.8, and 161 μg/l. At the end of the experiment, macrofauna established in control and experimental aquaria were examined. Mollusks, arthropods, and annelids were numerically dominant among the macrofauna. Although exposure to 1.8 μg/l PCP had no effect, the higher concentrations of PCP caused marked reduction in the numbers of individuals and species. Mollusks were the most sensitive taxonomic group to

PCP. These results and our previous studies on the effects of a nine-week exposure to PCP on the establishment of macrobenthic communities indicate that discharge of PCP into natural waters could alter the normal colonization by benthic animals and could impact various ecological relationships among localized populations.

236. Wilkes, Frank G. 1978. LABORATORY MICROCOSMS FOR USE IN DETERMINING POLLUTANT STRESS. In: Aquatic Pollutants: Transformation and Biological Effects, O. Hutzinger, I.H. Van Lelyveld, and B.C.J. Zeeteman, editors. Pergamon Press, New York. pp. 309-321. (ERL, GB Reprint #357).

Tests under development at ERL, GB to determine effects of pollutants on ecosystem compartments and processes are described. The tests are termed "microcosms" and are comprised of miniature ecosystems designed to investigate the origin, flow, fate, and effects of materials released in the environment. Examples of various tests and data obtained in their use are presented.

1977

237. Bahner, L.H., A.J. Wilson, J.M. Sheppard, J.M. Patrick, L.R. Goodman, and G.E. Walsh. 1977. KEPONE ACCUMULATION AND FOOD CHAIN TRANSFER. In: Proceedings of the Kepone Seminar II. U.S. EPA- Region III, Philadelphia, PA. pp. 294-329.

Accumulation, transfer, and loss of Kepone in estuarine organisms were studied in laboratory bioassays. Data show that Kepone was bioconcentrated by oysters (Crassostrea virginica), mysids (Mysidopsis bahia), grass shrimp (Palaemonetes pugio), sheepshead minnows (Cyprinodon variegatus), and spot (Leiostomus xanthurus) from concentrations as low as 0.023 μg/l seawater. Bioconcentration factors ranged from 10 to 340 in static exposures and 900 to 13,500 in flow-through bioassays and were dependent on species and exposure duration.

238. Butler, Philip A. 1977. NATIONAL ESTUARINE MONITORING PROGRAM. In: Estuarine Pollution Control and Assessment, Proceedings of a Conference, Vol. II. U.S. EPA, Office of Water Planning and Standards, Washington, DC. pp. 519-521. (ERL, GB Reprint #263).

About 8,000 samples of estuarine mollusks were monitored for pesticide residues in the period 1965-72. Residue trends and typical pollution situations are briefly described. Beginning in 1972, fish were substituted for mollusks. The basic needs for a continuing monitoring program are described.

239. Coppage, David L. 1977. ANTICHOLINESTERASE ACTION OF PESTICIDAL CARBAMATES IN THE CENTRAL NERVOUS SYSTEM OF POISONED FISHES. In: Physiological Responses of Marine Biota to Pollutants. Academic Press, Inc., New York, pp. 93-102. (ERL, GB Reprint #331).

In this report, kinetic enzyme methods and statistical analyses are used to define the relationship between brain acetylcholinesterase inhibition and near-median kills in replicate groups of marine fish in the laboratory by five carbamate pesticides.

240. Davis, William P., and D.P. Middaugh. 1977. IMPACT OF CHLORINATION PROCESSES ON MARINE ECOSYSTEMS. In: Estuarine Pollution Control and Assessment: Proceedings of a Conference, Vol. II. U.S. EPA, Office of Water Planning and Standards, Washington, DC. pp. 415-423. (ERL, GB Reprint #326).

The use of chlorine as a disinfectant and antifouling agent is reviewed. Chemical reactions of chlorine in aquatic environments are discussed, with particular emphasis on the formation of halogenated organic constituents in freshwater and marine systems. Studies of the effect of chlorinated sewage effluents and cooling water from generating stations on marine organisms and ecosystems are summarized.

241. Davis, William P., Betty S. Hester, Ruth L. Yoakum, and Richard G. Domey. 1977. MARINE ECOSYSTEM TESTING UNITS: DESIGN FOR ASSESSMENT OF BENTHIC ORGANISM RESPONSES TO LOW-LEVEL POLLUTANTS. International Symposium: Biologische Anstalt. Helgol. wiss. Meeresunters 30:673-681. (ERL, GB Reprint #321).

This paper describes Marine Ecosystem Testing Units (METU), an experimental design for integrating responses of communities of marine organisms to low-level pollutants under natural conditions of temperature, weather, season, precipitation, sunlight, etc. Ninety-six testing units are arranged in a regimen for pollutant exposure and systematic sampling. Organisms harvested are sorted and enumerated first to major taxa, subsequently to species level. Data are subjected to multi-variate statistical analysis to elucidate relative effects of pollutant, duration of test (harvest), season, and type of organism. Sampling is replicated in time and space. The first year of operation has demonstrated distinct responses to chlorination at levels below chemical detectability.

242. Duke, Thomas W. 1977. PESTICIDES IN AQUATIC ENVIRONMENTS: AN OVERVIEW. In: Pesticides in Aquatic Environments, Mohammed Abdul Quddus Khan, editor. Plenum Press, New York. pp. 1-8.

This general review covers subjects and issues under discussion at the Symposium for the International Congress of Entomology in Washington, DC, August 22, 1976. These issues include: state-of-the-art for extrapolating studies to the natural environment; possibility of generalizing pollutants in categories for "shortcut predictions"; need for research with unstressed aquatic systems; and the need to elucidate the more vital and vulnerable processes in aquatic systems to predict fate of pollutants in aquatic environments.

243. Garnas, R.L., A.W. Bourquin, and P.H. Pritchard. 1977. THE FATE AND DEGRADATION OF ^{14}C-KEPONE IN ESTUARINE MICROCOSMS. In: Proceedings of the Kepone Seminar II. U.S. EPA, Region III, Philadelphia, PA. pp. 330-362. (ERL, GB Reprint #351).

An investigation of the fate of ^{14}C-Kepone in static and continuous-flow estuarine microcosms is described. Kepone desorbed readily from salt-marsh sediments and James River sediments. While this desorption was independent of environmental temperatures and salinity ranges, Kepone residues in sediment influenced concentrations in the water column. Radioactivity was not extractable from some James River sediments with recognized analytical procedures. In larger continuous-flow systems, benthic polychaetes (Arenicola cristata) accumulated high residues of Kepone, died, and decomposed. These data should allow better prediction of the fate of Kepone in the aquatic environment.

244. Group IV (Thomas W. Duke, member). 1977. LONG-TERM EFFECTS OF ORGANIC POLLUTANTS ON ECOSYSTEMS. In: Ecosystem Processes & Organic Contaminants: Research Needs and an Interdisciplinary Perspective. U.S. Government Printing Office (GPO), Washington, DC. pp. 27-31.

Long-term effects of organic pollutants on ecosystems are discussed on the premise that metabolism, structure, and behavior are three unifying concepts common to all levels of organization from the cell to an ecosystem. The mandate to develop the capacity to extrapolate from microcosm to nature is clear. It is important to first ascertain what processes should be measured for the greatest extrapolation potential, and field verification of results should follow.

245. Hansen, D.J., and P.R. Parrish. 1977. SUITABILITY OF SHEEPSHEAD MINNOWS (CYPRINODON VARIEGATUS) FOR LIFE-CYCLE TOXICITY TESTS. Aquatic Toxicology and Hazard Evaluation, ASTM STP 634, F.L. Mayer and J.I. Hamelink, editors, American Society for Testing and Materials, pp. 117-126. (ERL, GB Reprint #301).

Entire life-cycle toxicity tests are practical with sheepshead minnows, Cyprinodon variegatus. This is the only estuarine fish that has been utilized successfully in life-cycle toxicity test methods formulated since 1973. Salinity, temperature, and spawning requirements were determined, and initial life-cycle toxicity tests with endrin were conducted at the Environmental Research Laboratory, Gulf Breeze. Subsequent tests with heptachlor, carbofuran, methoxychlor, and malathion were conducted at Gulf Breeze or at EG&G, Bionomics. All studies confirmed the feasibility of using this estuarine fish for determining maximum acceptable toxicant concentrations and application factors. Results of our tests also corroborate data on application factors obtained in studies completed elsewhere with freshwater fishes and the same pesticides.

246. Hansen, D.J., D.R. Nimmo, S.C. Schimmel, G.E. Walsh, and A.J. Wilson, Jr. 1977. EFFECTS OF KEPONE® ON ESTUARINE ORGANISMS. In: Proceedings of the Kepone Seminar II. U.S. EPA, Region III, Philadelphia, PA. pp. 266-282. (ERL, GB Reprint #311).

Effects of Kepone and its accumulation are investigated in toxicity tests with estuarine algae, mollusks, and crustaceans. These tests indicate that chronic toxicity and bioconcentration potential of Kepone are more important factors than its acute toxicity in laboratory evaluations of environmental hazard. These factors should be considered in assessing impacts and attempting to limit future impacts of this insecticide on the aquatic environment.

247. Huggett, Robert J. 1977. THE ROLE OF SEDIMENTS IN THE STORAGE, MOVEMENT, AND BIOLOGICAL UPTAKE OF KEPONE IN ESTUARINE ENVIRONMENTS. In: Proceedings of the Kepone Seminar II. U.S. EPA, Region III, Philadelphia, PA. pp. 363-456.

This report describes the Virginia Institute of Marine Science staff's investigation of the role of sediments in the storage, movement, and biological uptake of Kepone in estuarine environments. Results are presented in three sections titled: "Kepone in James River Sediment," by Maynard M. Nichols and Richard C. Trotman; "Kepone Water-Sediment Elutriates," by Robert J. Huggett; and "Uptake of Kepone from Suspended Sediments by Oysters, *Rangia* and *Macoma*," by Dexter S. Haven and Reinaldo Morales-Alamo. The report is included in Proceedings of Kepone Seminar II sponsored by EPA, the National Marine Fisheries Service, and NOAA in Easton, MD, September 19-21, 1977.

248. Nimmo, Del Wayne R., and Lowell H. Bahner. METALS, PESTICIDES AND PCB's: TOXICITIES TO SHRIMP SINGLY AND IN COMBINATION. In: Estuarine Processes, Vol. 1, Uses, Stresses, and Adaptation to the Estuary, Martin W. Wiley, editor. Academic Press, New York. pp. 523-532. (ERL, GB Reprint #271).

This study examines potential deleterious effects of certain toxicants, singly and in combination, to penaeid shrimp. In nature, these shrimp are exposed to combinations of toxicants from industrial and municipal outfalls, from agricultural runoff, or from dredge-and-fill operations.

The combined toxicities of methoxychlor and cadmium to penaeid shrimp, *Penaeus duorarum*, were either independent or additive, and varied with the method(s) of bioassay. Conclusions were based on the results of 10-, 25- and 30-day bioassays conducted with the toxicants added singly or in combination to flowing water of constant salinity and temperature.

Cadmium, but not methoxychlor, was accumulated by shrimp, and methoxychlor appears to influence the processes of accumulation or loss of cadmium from tissues of shrimp.

249. Nimmo, Del Wayne R., Donald V. Lightner, and Lowell H. Bahner. 1977. EFFECTS OF CADMIUM ON THE SHRIMPS, PENAEUS DUORARUM, PALAEMONETES PUGIO, AND PALAEMONETES VULGARIS. In: Physiological Responses of Marine Biota to Pollutants. Academic Press Inc., New York, pp. 131-183. (ERL, GB Reprint #332).

Data from this experiment show that grass shrimp, Palaemonetes vulgaris, were acutely and chronically more sensitive to cadmium than the pink shrimp, Penaeus duorarum. Bioaccumulation of cadmium from water occurred at concentrations as low as 2 μg/l in P. duorarum and 7.9 μg/l in P. vulgaris. Pink shrimp, exposed to cadmium concentrations near LC50's, consistently developed blackened foci or blackened lamelae on the branchia. When the brine shrimp, Artemia, containing cadmium were used as food, the transfer of cadmium to grass shrimp was much less efficient than transfer of cadmium directly from the water. To produce equivalent whole-body residues in the shrimp, about 15,000 times more cadmium must be introduced in food than could be obtained from seawater.

250. Nimmo, D.R., L.H. Bahner, R.A. Rigby, J.M. Sheppard, and A.J. Wilson, Jr. 1977. MYSIDOPSIS BAHIA: AN ESTUARINE SPECIES SUITABLE FOR LIFE-CYCLE TOXICITY TESTS TO DETERMINE THE EFFECTS OF A POLLUTANT. Aquatic Toxicology and Hazard Evaluation, ASTM STP 632, F.L. Mayer and J.L. Hamelink, editors. American Society for Testing Materials, pp. 109-116. (ERL, GB Reprint #296).

This study documents the successful use of a mysid, Mysidopsis bahia, for life-cycle toxicity tests. These tests were conducted to determine acute and chronic toxicities of metal (cadmium) and pesticide (Kepone). Delay in the formation of mysid brood pouches and release of young were noted in low concentrations $\leq$6.4 μg/l cadmium. Fewer young produced per female and decreased growth were other indicators of effects of Kepone.

251. O'Connor, Donald J., and Kevin J. Farley. 1977. PRELIMINARY ANALYSIS OF KEPONE DISTRIBUTION IN THE JAMES RIVER. In: Proceedings of the Kepone Seminar II. U.S. EPA, Region III, Philadelphia, PA. pp. 457-480.

Significant concentrations of Kepone are shown to be present in various phases of the estuarine system--in solution, in suspension, in sediment, and in the food chain--of the James River, VA. Further work will attempt to provide a quantitative framework to evaluate time required to reduce Kepone concentrations to acceptable levels.

252. Parrish, Patrick R., James M. Patrick, Jr., and Jerrold Forester. 1977. EFFECTS OF THREE TOXICANTS ON OYSTERS (CRASSOSTREA VIRGINICA) EXPOSED CONTINUOUSLY FOR TWO YEARS. Proc. Natl. Shellfish Assoc. 67:121-122. (ERL, GB Reprint #347).

Three separate populations of oysters were exposed continuously for 104 weeks in flowing, natural seawater in the laboratory to 0.01 μg/l of Aroclor® 1254 or p,p'-DDT and its metabolites, or dieldrin. Maximum residues (based on μg of toxicant per g of tissue) occurred after 8 weeks of exposure; average whole-body residues (wet weight) of five oysters from each treatment analyzed individually were: Aroclor® 1254, 1.65 μg/g; DDT (and metabolites DDD and DDE), 0.46 μg/g; and dieldrin, 0.08 μg/g. Seasonal patterns of accumulation and loss of the three toxicants were similar and were apparently related to spawning. Toxicant residues decreased 45 to 81% in early July and late October, 1972, and 44 to 91% in late October, 1973. Growth rate (height and in-water weight) of exposed oysters was not significantly different from that of control oysters (Student's t-test; $P<0.05$) after 72 weeks of exposure. Mortality was not significant ($\leq$9%) in any group during the entire study.

253. Schimmel, S.C., and A.J. Wilson, Jr. 1977. ACUTE TOXICITY OF KEPONE TO FOUR ESTUARINE ANIMALS. In: Proceedings of the Kepone Seminar II. U.S. EPA, Region III, Philadelphia, PA. pp. 283-294. (ERL, GB Reprint #293).

Kepone contamination of the James River estuary, VA, prompted acute flowthrough bioassays to determine 96-hr toxicity of Kepone to four estuarine species. The 96-hr LC50 values for species tested follow: grass shrimp (*Palaemonetes pugio*), 121 μg/l; blue crab (*Callinectes sapidus*), 210 μg/l; sheepshead minnow (*Cyprinodon variegatus*), 69.5 μg/l; and spot (*Leiostomus xanthurus*), 6.6 μg/l. Surviving animals were analyzed for Kepone. Average bioconcentration factors (the concentration of Kepone in tissues divided by the concentration of Kepone measured in seawater) were: grass shrimp, 698; blue crab 8.1; sheepshead minnow, 1,548; and spot, 1,221.

254. Schimmel, S.C., J.M. Patrick, Jr., and A.J. Wilson, Jr. 1977. ACUTE TOXICITY TO AND BIOCONCENTRATION OF ENDOSULFAN BY ESTUARINE ANIMALS. In: Aquatic Toxicology and Hazard Evaluation, ASTM STP 634, F.L. Mayer and J.L. Hamelink, editors. American Society for Testing Materials, pp. 241-252. (ERL, GB Reprint #289).

Acute (96-hr) flow-through toxicity tests with endosulfan (Thiodan) were conducted with several estuarine animals. The test species and their 96-hr lethal concentration for 50% of the organisms (LC50) values were: pink shrimp (*Penaeus duorarum*), 0.04 μg/l; grass shrimp (*Palaemonetes pugio*), 1.3 μg/l; pinfish (*Lagodon rhomboides*), 0.3 μg/l; spot (*Leiostomus xanthurus*), 0.09 μg/l; and striped mullet (*Mugil cephalus*), 0.38 μg/l. In a 56-day bioconcentration study (28-day uptake, 28-day depuration), striped mullet were exposed to 0.008 and 0.08 μg endosulfan/l seawater. The two endosulfan isomers (endosulfan I and II) were rapidly metabolized to endosulfan sulfate; only trace amounts of each isomer were detected in edible tissue or offal of mullet exposed to 0.08 μg/l (0.035 μg/l measured) for 28 days. Our studies suggest that endosulfan in the estuarine environment would be a hazard because of its acute toxicity and bioconcentration potential, but animals surviving exposure and moving to areas free of endosulfan would lose the chemical rapidly.

1976

255. Couch, John A. 1976. ATTEMPTS TO INCREASE BACULOVIRUS PREVALENCE IN SHRIMP BY CHEMICAL EXPOSURE. In: Progress in Experimental Tumor Research, F. Homburger, editor. S. Karger, Basel, Switzerland. 20: 304-314. (ERL, GB Reprint #240).

    The shrimp-virus system is described, particularly in regard to the physical, chemical, and biological characterization of the virus and interactive effects of the virus and chemical agents, such as pesticides and PCB's. Results are reported of test exposures of samples of shrimp to several pesticides and industrial chemicals identified as stressing pollutants in aquatic ecosystems: Aroclor 1254® (PCB), mirex (insecticide), methoxychlor (insecticide), and cadmium (metal).

256. Crow, S.A., W.L. Cook, and D.G. Ahearn. 1976. MICROBIAL POPULATIONS IN COASTAL SURFACE SLICKS. In: Proceedings Third International Biodegradation Symposium, J.M. Sharpley and A.M. Kaplan, editors. Applied Science Publishers Ltd., London. pp. 93-98. (ERL, GB Reprint #254).

    Samples of the upper 10 μm of inshore surface films obtained by adsorption to membranes yielded microbial populations up to 10^8 ml^{-1} or 10^5 cm^{-2}. These populations were typically 10-100 times greater than those in underlying waters at a depth of 10 cm. Predominant bacteria in surface films were motile, nonpigmented, gram-negative rods. Colony-forming units of yeasts and moulds were found in concentrations to 10^4 ml^{-1} or 28 cm^{-2}. The predominant species in surface films were proteolytic and amylolytic but exhibited only weak to negligible hydrocarbonoclastic and lipolytic activities. A greater proportion of the surface film bacteria, as compared to those at 10 cm depth, were capable of growth on fresh-water media.

257. Davies, Tudor T. 1976. ENERGY-RELATED GREAT LAKES RESEARCH PROGRAMS OF THE ENVIRONMENTAL PROTECTION AGENCY. In: Proc. Second Fed. Conf. on the Great Lakes, J.S. Marshall, editor. Interagency Committee on Marine Science and

Engineering of the Federal Council for Science and Technology (ICMSE), Argonne National Laboratory, Chicago, IL. pp. 499-531.

> EPA research applicable to the Great Lakes are reviewed. Activities include: national programs based on the theme of the March 1975 Federal Conference on the Great Lakes; new and accelerated national initiatives in energy research and development; and specific projects related to the water quality of the lakes.

258. Duke, Thomas W. 1976. CYCLING OF POLLUTANTS. In: Estuarine Processes, Vol. 1, Uses, Stresses, and Adaptation to the Estuary, Martin W. Wiley, editor. Academic Press, New York. pp. 481-482. (ERL, GB Reprint #320).

> Environmental distribution of pesticides, their pathways of transfer and bioaccumulation, are known in many instances, yet their ultimate effects on organisms are relatively unknown. Importance of the impact of oil, heavy metals, and pesticides on ecosystems and on biological systems ranging from micro-organisms to fishes is emphasized in this introduction to a symposium on the "Cycling of Pollutants," convened by Thomas W. Duke at Galveston, TX, under the sponsorship of Estuarine Research Federation, October 9, 1975. The combined toxicities of methoxychlor, cadmium, and polychlorinated biphenyls are discussed.

259. Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP), (David J. Hansen, member). 1976. WORKING GROUP ON THE PRINCIPLES FOR DEVELOPING COASTAL WATER QUALITY CRITERIA. Food and Agriculture Organization (FAO), United Nations. GESAMP VIII/6. 23 p. (ERL, GB Reprint #270).

> This document records the working group's second session held October 20-25, 1975, in Dubrovnik, Yugoslavia, to discuss coastal water criteria. Members agreed to attempt to develop criteria for specific compounds, such as DDT and petroleum hydrocarbons, as examples for the application of principles. Principles applicable to the development and application of water quality criteria are presented.

260. Nimmo, Del Wayne R. 1976. POLYCHLORINATED BIPHENYLS (PCB). Hearings before the Subcommittee on Fisheries and Wildlife Conservation and the Environment of the Committee on Merchant Marine and Fisheries, House of Representatives. U.S. Government Printing Office, Washington, DC. Serial No. 94-24. (ERL, GB Reprint #299).

> Research conducted by EPA at its Environmental Research Laboratory, Gulf Breeze, on PCB's in estuarine environment is described. Data presented show that PCB's: (1) occur in the marine environment, (2) are readily dispersed from point sources, (3) are relatively persistent, and (4) are concentrated in animals, plants, and sediments. Controlled experiments conducted in the laboratory indicate: (1) various PCB's are toxic (at the ppb level in water) to shrimp, fish, and other organisms, (2) animals can

obtain PCB's from water, sediment, or food organisms, and (3) these chemicals are bioaccumulated.

261. Nimmo, Del Wayne R., and Lowell H. Bahner. 1976. METALS, PESTICIDES, AND PCB'S: TOXICITIES TO SHRIMP SINGLY AND IN COMBINATION. In: Estuarine Processes, Vol. 1, Uses, Stresses, and Adaptation to the Estuary, Martin W. Wiley, editor. Academic Press, New York. pp. 523-532. (ERL, GB Reprint #271).

The objective of this study was to assess potential deleterious effects of certain toxicants, singly and in combination, to penaeid shrimp. In nature, these shrimp are exposed to combinations of toxicants from industrial and municipal outfalls, from agricultural runoff or from dredge-and-fill operations. The combined toxicities of methoxychlor and cadmium to penaeid shrimp, Penaeus duorarum, were either independent or additive, and varied with the method(s) of bioassay. Conclusions were based on the results of 10-, 25- and 30-day bioassays conducted with the toxicants added singly or in combination to flowing water of constant salinity and temperature. Cadmium, but not methoxychlor, was accumulated by shrimp and methoxychlor appears to influence the processes of accumulation or loss of cadmium from tissues of shrimp.

262. Walsh, Gerald, Samuel Snedaker, and Howard Teas, editors. 1976. PROCEEDINGS OF INTERNATIONAL SYMPOSIUM ON BIOLOGY AND MANAGEMENT OF MANGROVES, Vols. I and II. Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL. 846 p. (ERL, GB Reprint #290).

These volumes contain proceedings of the International Symposium on Biology and Management of Mangroves held October 8-11, 1974, at the East-West Center in Honolulu, Hawaii. Participants describe the biogeography, biology, geomorphology and soils, anatomy, and physiology of mangroves and also discuss some effects resulting from man's use of these resources.

1975

263. Bahner, Lowell H., and Del Wayne R. Nimmo. 1975. METHODS TO ASSESS EFFECTS OF COMBINATIONS OF TOXICANTS, SALINITY AND TEMPERATURE ON ESTUARINE ANIMALS. In: Trace Substances in Environmental Health-IX: a Symposium, June 10-12, 1975. University of Missouri, Columbia, MO. pp. 169-177. (ERL, GB Reprint #259).

Aquatic species are exposed to toxicants singly, but more often in combinations, under varying environmental regimes. Consequently, an experimental flowing-water bioassay system was developed to control salinity and temperature while testing toxicants either singly or in combination. These controls allow rates of toxicant accumulation, translocation, loss, or acute and chronic toxicity to animals to be better assessed. Our bioassays were conducted with pink shrimp (*Penaeus duorarum*) exposed to the following toxicant combinations: cadmium-malathion, cadmium-methoxychlor, cadmium-methoxychlor-Aroclor® 1254 and a complex that contained both inorganic and organic constituents. The toxicities of the pesticide-metal combinations, when compared to those of each constituent singly, appeared to be independent of each other.

264. Couch, John A. 1975. DISCUSSION FROM SELECTED PAPERS PRESENTED AT EPA-USDA WORKING SYMPOSIUM. In: *Baculoviruses* for Insect Pest Control: Safety Considerations, Max D. Summers, Rilo Engler, Louis A. Falcon, and Patrick Vail, editors. Am. Soc. Microbiol., Washington, DC. pp. 58-62, 111-114. (ERL, GB Reprint #262).

Importance of a critical investigation from a conceptual point of view of *baculoviruses*, particularly in regard to crustacea, is discussed. Questions are posed regarding the chief criteria of their effects and whether scientists should investigate latent infections, other sublethal effects, and possible infections from these insecticides in larval nontarget species (i.e., crustacea). Discussions at the EPA-USDA symposium held April 15-18, 1974, in Bethesda, MD, also center on the urgent need to publish results of tests and test methods used in investigating the impact of insect viruses on noninsect invertebrates.

265. Couch, John A. 1975. HISTOPATHOLOGICAL EFFECTS OF PESTICIDES AND RELATED CHEMICALS ON THE LIVERS OF FISHES. In: The Pathology of Fishes, William E. Ribelin and George Migski, editors. The University of Wisconsin Press, Madison, WI. pp. 559-584. (ERL, GB Reprint #152).

Evidence for the accumulation of pesticides in aquatic ecosystems is abundant. Certain pesticides (i.e., organochlorines and their metabolites) accumulate in fish, particularly in liver and fatty tissues. This paper reviews the histopathology of the livers of fishes in reference to pesticide exposure.

266. Parrish, Patrick R., Gary H. Cook, and James M. Patrick, Jr. 1975. HEXACHLOROBENZENE: EFFECTS ON SEVERAL ESTUARINE ANIMALS. Proc. 28th Annu. Conf. Southeast. Assoc. Game Fish Comm. pp. 179-186. (ERL, GB Reprint #226).

Tests were conducted to determine (1) the acute (96-hr) toxicity of hexachlorobenzene (HCB) to pink shrimp (*Penaeus duorarum*), grass shrimp (*Palaemonetes pugio*), sheepshead minnows (*Cyprinodon variegatus*), and pinfish (*Lagodon rhomboides*) and (2) the rate of HCB uptake and depuration by pinfish. Hexachlorobenzene was not acutely toxic to any of the animals tested at measured concentrations in seawater to 25 μg/1. However, both species of shrimps in the highest HCB concentration were lethargic as compared to controls and exhibited an uncharacteristically white hepatopancreas at the end of the 96-hr exposure. Pinfish exposed to average measured HCB concentrations of 0.06, 0.15, 0.65, 1.87, or 5.2 µg/1 for 42 days accumulated the compound throughout the exposure. Maximum residue in muscle (wet-weight) was 34,000X the measured concentration in test water. Pinfish retained most (>50%) of the HCB after a 28-day depuration period in HCB-free water.

267. Schimmel, Steven C., and David J. Hansen. 1975. SHEEPSHEAD MINNOW (*CYPRINODON VARIEGATUS*): AN ESTUARINE FISH SUITABLE FOR CHRONIC (ENTIRE LIFE-CYCLE) BIOASSAYS. Proc. 28th Ann. Conf. Southeast. Assoc. Game Fish Comm. pp. 392-398. (ERL, GB Reprint #205).

The sheepshead minnow (*Cyprinodon variegatus*), an estuarine fish of the Atlantic and Gulf Coasts, is suitable for both partial chronic and chronic (egg-to-egg) bioassays. The fish is easily held at high population densities in the laboratory, and at about 30°C, produces numerous eggs. The average 30-day survival of the fish from fertile egg to fry is 75%. Generation time for this species is short (3-4 months) and its small adult size (male average standard length = 48 mm) provides for relatively inexpensive bioassays. This killifish's susceptibility to organochlorine toxicants is similar to that of other estuarine fishes tested and thus should produce significant information on the effects of these toxicants on the estuarine community.

268. Schimmel, Steven C., Patrick R. Parrish, David J. Hansen, James M. Patrick, Jr. and Jerrold Forester. 1975. ENDRIN: EFFECTS ON SEVERAL ESTUARINE ORGANISMS. Proc. 28th Annu. Conf. Southeast. Assoc. Game Fish Comm. pp. 187-194. (ERL, GB Reprint #218).

Acute (96-hr) bioassays were performed ith endrin and the following estuarine organisms: American oyster (*Crassostrea virginica*), pink shrimp (*Penaeus duorarum*), grass shrimp (*Palaemonetes pugio*), sailfin molly (*Poecilia latipinna*), and sheepshead minnow (*Cyprinodon variegatus*). Endrin was acutely toxic to all organisms tested, except oysters, whose shell growth was appreciably inhibited by 56 µg/1 ppb of the chemical. Pink shrimp were the most sensitive animal tested, but significant numbers of both species of shrimps and fishes died when exposed to concentrations of one µg/1 or less. In a separate test, embryos and fry of the sheepshead minnow were exposed to concentrations of endrin ranging from 0.046 to 1.0 µg/1 (nominal) for 33 days in an intermittant-flow bioassay. Embryos were not affected by the concentrations to which they were exposed, but the estimated LC50 (probit analysis, $\alpha = 0.05$) of fry was 0.27 µg/1.

1974

269. Atema, Jelle, Charles C. Coutant, Patricia DeCoursey, David Hansen, James S. Kittredge, John J. Magnuson, Don Miller, Bori L. Olla, Mark J. Schneider, and Winona B. Vernberg. 1974. BEHAVIORAL BIOASSAYS. In: Marine Bioassays. Proceedings of Workshop Sponsored by the Marine Technology Society, Washington, DC. pp. 1-31. (ERL, GB Reprint #251).

    This workshop focuses on various aspects of applying behavioral measures to water quality bioassay techniques. Although in a few instances the use of behavioral bioassays has reached the standard test stage, the state-of-the-art is very young. Consequently, the scope of this discussion is intended as a beginning in the integration of a variety of basic research techniques into logical steps in development of standard tests.

270. Butler, Philip A. 1974. TRENDS IN PESTICIDE RESIDUES IN SHELLFISH. Proc. Natl. Shellfish. Assoc. 64:77-81. (ERL, GB, Reprint #176).

    The National Estuarine Monitoring Program, a cooperative effort between the State and Federal Governments, collected and analyzed shellfish samples for persistent synthetic pesticides at monthly intervals during the years 1965-1972 in 15 coastal states. The recently completed study of the 8000-plus analyses reveals: (1) residues, primarily DDT and its metabolites, that are too low to have human health significance, (2) areas of both high and low residues that were clearly defined geographically, (3) a trend in some areas towards a wider distribution of smaller residues, and (4) a marked decline generally in DDT residues since peak levels in mollusks were detected in 1968.

271. Butler, Philip A. 1974. ESTUARIES. In: Guidelines on Sampling and Statistical Methodologies for Ambient Pesticide Monitoring. Federal Working Group on Pest Management, Washington, DC. pp. V1-V5. (ERL, GB Reprint #245).

    Estuarine monitoring objectives are defined for specific program objectives. The decision to monitor an estuary for pesticides may derive from one or several specific needs that will largely determine the character and _modus operandi_ of the monitoring program.

272. Couch, John, and D.R. Nimmo. 1974. DETECTION OF INTERACTIONS BETWEEN NATURAL PATHOGENS AND POLLUTANTS IN AQUATIC ANIMALS. Proc. Gulf Coast Regional Symposium on Diseases of Aquatic Animals, Baton Rouge, LA, April 16-17, 1974. Center for Wetland Resources, Louisiana State University, LSU-SG-74-05, pp. 261-268. (ERL, GB Reprint #219).

    This paper presents two examples of the detection of possible interactions between natural pathogens and chemical pollutants in selected Gulf of Mexico estuarine animals. Results of experimental laboratory work and field observations of the pink shrimp (Penaeus duorarum) and the shrimp virus (Baculovirus penaei) in the vicinity of Gulf Breeze, FL, are described.

273. Couch, John A., and Del Wayne R. Nimmo. 1974. ULTRASTRUCTURAL STUDIES OF SHRIMP EXPOSED TO THE POLLUTANT CHEMICAL POLYCHLORINATED BIPHENYL (AROCLOR 1254). Bull. Soc. Pharmacol. Environ. Path. 11(2):17-20. (ERL, GB Reprint #216).

This paper, presented at the 63rd annual meeting of the International Academy of Pathology, March 13, 1974, in San Francisco, CA, describes ultrastructural studies of shrimp exposed to the chemical polychlorinated biphenyl (PCB), Aroclor 1254. In experiments at ERL, GB, the pink shrimp (Penaeus duorarum), exposed for 30 to 50 days to 3 μg of polychlorinated biphenyls (PCB) per liter in flowing seawater, accumulated up to 40 mg of PCB per kg in hepatopancreatic tissue. Light and electron microscopy of shrimp surviving 30-day exposure revealed two forms of hepatopancreatic cellular alterations that may reflect toxic responses. The most prevalent cytopathic alteration was the occurrence of small (20 to 50 nm) and large (100 to 700 nm) vesicles in nuclei of absorptive cells. The other significant difference between exposed and control shrimp was the presence of a Baculovirus in 5 to 8% of the hepatopancreatic nuclei of exposed shrimp. This virus was associated with several nuclear and cytoplasmic alterations, and is the first Baculovirus to be reported in animals other than insects or mites.

274. Couch, John A., George Gardner, John Harshbarger, M.R. Tripp, and Paul Yevich. 1974. HISTOLOGICAL AND PHYSIOLOGICAL EVALUATIONS IN SOME MARINE FAUNA. In: Marine Bioassays. Proceedings of Workshop Sponsored by the Marine Technology Society, Washington, DC. pp. 156-173. (ERL, GB Reprint #250).

The development of pathology, as applied to aquatic toxicology, depends heavily on the knowledge of normal histology and physiology if anomalies due to pollutants or disease are to be accurately defined. However, at present, knowledge of normal morphology or metabolic activities is either incomplete or lacking for most marine or coastal organisms.

This paper presents techniques and examples of methods required to characterize and interpret the morphological or physiological responses of aquatic organisms to various factors, including pollutants.

275. Cross, F.A., and T.W. Duke. 1974. CONTAMINATION OF MARINE RESOURCES FOR HUMAN CONSUMPTION. In: Marine Bioassays. Proceedings of Workshop Sponsored by the Marine Technology Society, Washington, DC. pp. 32-108.

This workshop panel deals with research and monitoring needs for current and potential residue problems in marine organisms. Long-term effects of contaminants on marine ecosystems also are considered. Special needs and research problems are assessed for petroleum hydrocarbons, toxic metals, and synthetic organic compounds.

276. Duke, Thomas W., and David P. Dumas. 1974. IMPLICATIONS OF PESTICIDE RESIDUES IN THE COASTAL ENVIRONMENT. In: Pollution and Physiology of Marine Organisms, F. John Vernberg and Winona B. Vernberg, editors. Academic Press, New York. pp. 137-164. (ERL, GB Reprint #195).

The coastal zone interfaces with man's activities on land and, therefore, is especially susceptible to exposure to acute doses of degradable pesticides, as well as chronic doses of persistent ones. This paper reports the state-of-the-art of research on the effects of pesticides on coastal aquatic organisms.

277. Hansen, David J., Steven C. Schimmel, and Jerrold Forester. 1974. AROCLOR® 1254 IN EGGS OF SHEEPSHEAD MINNOWS: EFFECT ON FERTILIZATION SUCCESS AND SURVIVAL OF EMBRYOS AND FRY. Proc. 27th Annu. Conf. Southeast. Assoc. Game Fish Comm. pp. 420-426. (ERL, GB Reprint #177).

The effect of the polychlorinated biphenyl (PCB), Aroclor 1254, in eggs of the sheepshead minnow, Cyprinodon variegatus, on fertilization success and survival of embryos and fry was investigated. Adult fish were exposed for four weeks to 0.1, 0.32, 1.0, 3.2, or 10.0 μg/l of PCB, then injected twice with 50 IU of human chorionic gonadotrophin to stimulate egg production. The eggs were fertilized, placed in PCB-free flowing seawater and observed for mortality. Fertilization success was unimpaired by concentrations in eggs as high as 201 μg/g but survival of embryos and fry was reduced. If this PCB affects other species similarly, then populations of fish that presently have comparable concentrations in their eggs may be endangered.

278. Murray, E. Don, and Al W. Bourquin, editors. 1974. DEVELOPMENTS IN INDUSTRIAL MICROBIOLOGY, Vol. 15. Am. Instit. Biological Sciences, Washington, DC. 426 p. (ERL, GB Reprint #244).

Contributed papers and symposia presented at the 30th general meeting of the Society for Industrial Microbiology at Evanston, IL, on August 19-24, 1973, are included in this volume. Participants discuss both basic and practical aspects of microbiological research. Environmental problems, such as the detection of viruses in waste water, are among the subjects under discussion.

279. Nimmo, D.R., and L.H. Bahner. 1974. SOME PHYSIOLOGICAL CONSEQUENCES OF POLYCHLORINATED BIPHENYL- AND SALINITY-STRESS IN PENAEID SHRIMP. In: Pollution and Physiology of Marine Organisms, F. John Vernberg and Winona B. Vernberg, editors. Academic Press, New York. pp. 427-443. (ERL, GB Reprint #198).

This paper is concerned with the possible interaction of Aroclor® 1254 and environmental stress, particularly the effect of PCB on the ability of shrimp to regulate osmotically and ionically at reduced salinities.

280. Parrish, Patrick R. 1974. AROCLOR® 1254, DDT, DDD, AND DIELDRIN: ACCUMULATION AND LOSS BY AMERICAN OYSTERS (CRASSOSTREA VIRGINICA) EXPOSED CONTINUOUSLY FOR 56 WEEKS. Proc. Nat. Shellfish. Assoc. 64:7. (ERL, GB Reprint #174).

Separate populations of oysters were exposed continuously for 56 weeks to 0.01 μg/l of Aroclor® 1254, p,p'-DDT and DDD, or dieldrin and sampled at 8-week intervals for residues. Maximum concentrations based on body weight (μg/g) occurred after 8 weeks exposure, but maximum concentrations based on absolute amount of toxicant accumulated (μg) occurred after 56 weeks of exposure. After 8 weeks, average whole-body residues (wet weight) from five oysters analyzed individually were: Aroclor 1254, 1.65 μg/g, 4.0 μg; DDT (and metabolites DDD and DDE), 0.46 μg/g, 1.0 μg; and dieldrin, 0.08 μg/g, 0.2 μg. After 56 weeks, residues were: Aroclor 1254, 0.89 μg/g, 25.7 μg; DDT and metabolites, 0.37 μg/g, 7.0 μg; and dieldrin, 0.03 μg/g, 0.6 μg. Seasonal patterns of accumulation and loss of the three toxicants were similar. Residues based on body weight (μg/g) decreased 45-81% in early July and late October, apparently as the result of spawning, and increased following these periods. This investigation shows that the life history of oysters must be considered when evaluating residue data from monitoring programs.

281. Parrish, Patrick R., John A. Couch, Jerrold Forester, James M. Patrick, Jr., and Gary H. Cook. 1974. DIELDRIN: EFFECTS ON SEVERAL ESTUARINE ORGANISMS. Proc. 27th Annu. Conf. Southeast. Assoc. Game Fish Comm. pp. 427-434. (ERL, GB Reprint #178).

Tests were conducted to determine (1) the acute toxicity of dieldrin in flowing seawater to American oysters (*Crassostrea virginica*), pink shrimp (*Penaeus duorarum*), grass shrimp (*Palaemonetes pugio*) and sheepshead minnows (*Cyprinodon variegatus*) and (2) the rate of dieldrin uptake and depuration by spot (*Leiostomus xanthurus*). Acute (96-hr) EC50's were: oysters, 12.5 μg/l; pink shrimp, 0.9 μg/l; grass shrimp, 11.4 μg/l; and sheepshead minnows 23.6 μg/l. Spot exposed to 0.0135, 0.075, 0.135, 0.75 or 1.35 μg/l for 35 days accumulated the chemical with maximum concentrations attained in 11 to 18 days. Maximum whole-body residue (wet-weight) was 6,000X the concentration in test water. Spot contained no detectable dieldrin residues at the end of a 13-day depuration period in dieldrin-free water. Tissue alterations, such as subepithelial edema in gill lamellae and severe lysis and sloughing of the small intestine epithelium, occurred in spot exposed to 1.35 μg/l for four days.

282. Walsh, Gerald E. 1974. MANGROVES: A REVIEW. In: Ecology of Halophytes, W. Ribelin and G. Migaki, editors. University of Wisconsin Press, Madison Wisconsin, pp. 51-174. (ERL, GB Reprint #154).

This review describes mangrove vegetation and its ecosystem. It is included in the proceedings of a symposium, Physiological Ecology of Halophytes, held under auspices of the Physiological Ecology section of the Ecological Society of America in August 1972 at the University of Minnesota.

1973

283. Bourquin, A.W. 1973. ESTUARINE MICROBES AND ORGANOCHLORINE PESTICIDES (A BRIEF REVIEW). In: The Microbial Degradation of Oil Pollutants, D.G. Ahearn and S.P. Meyers, editors. Center for Wetland Resources, Louisiana State University, Baton Rouge, LA. LSU-SG-73-01, pp. 237-243. (ERL, GB Reprint #165).

Little is known about microbiological degradation of organochlorine pesticides in estuarine and oceanic environments. This paper reviews areas of research required to further elucidate microbial degradation processes in aquatic environments. Such data are needed to determine the role of microorganisms on the fate of organic pollutants.

284. Buckley, John L., and Tudor T. Davies. 1973. THE ENVIRONMENTAL PROTECTION AGENCY'S ROLE IN GREAT LAKES RESEARCH. Proceedings of the First Federal Conference on the Great Lakes, Tudor T. Davies, editor. Great Lakes Basin Commission, Ann Arbor, MI. pp. 78-82.

This paper describes EPA's responsibilities in supporting research to further understand the water system as a basis for a comprehensive management system for the Great Lakes. Task-oriented research in the Great Lakes region and national research efforts relevant to the Great Lakes are discussed.

285. Cooley, Nelson R. 1973. EFFECTS OF PESTICIDES ON PROTOZOA. In: Progress in Protozoology, Fourth International Congress of Protozoology, Universite de Clermont, UER-Sciences Exactes et Naturelles, Clermont-Ferrand, France, September 2-9, 1973. p. 91. (ERL, GB Reprint #202).

Results of studies of the effects of mirex and three polychlorinated biphenyls on protozoa are presented. The data suggest that pesticides and related toxicants entering aquatic ecosystems could reduce the availability of ciliates as food and as nutrient regenerators, thereby disrupting nutrient cycles and perhaps altering species composition of ciliate communities. The ability of responsive ciliates to accumulate persistent compounds could permit translocation of the chemicals through food chains. In this manner, effects of the chemicals could be exerted at higher trophic levels.

286. Davies, Tudor T., editor. 1973. PROCEEDINGS OF THE FIRST FEDERAL CONFERENCE ON THE GREAT LAKES. Great Lakes Basin Commission, Ann Arbor, MI. 334 p.

Delegates to the First Federal Conference on the Great Lakes define the magnitude and rationale of federal agency activities on the Great Lakes. Conferees represent federal agencies comprising the Interagency Committee on Marine Science and Engineering (ICMSE), sponsor of sessions held December 13-15, 1972, in Ann Arbor, MI.

287. Davies, Tudor T., and Nelson A. Thomas. 1973. GREAT LAKES PROGRAMS OF THE GROSSE ILE LABORATORY. Proceedings of the First Federal Conference on the Great Lakes, Tudor T. Davies, editor. Great Lakes Basin Commission, Ann Arbor, MI. pp. 82-89.

U.S. EPA research on the Great Lakes, directed by its Grosse Ile Laboratory, is described. Specific research needs addressed in the planned program are defined. Program objectives are concerned with: eutrophication and nutrient control; predictive management models for the transport of nutrients, hazardous material, and other pollutants; and the evaluation of the ecological impact of thermal pollution of the Lakes.

1972

288. Butler, Philip A., Ray Childress, and Alfred J. Wilson. 1972. THE ASSOCIATION OF DDT RESIDUES WITH LOSSES IN MARINE PRODUCTIVITY. In: Marine Pollution and Sea Life, Mario Ruivo, editor. Fishing News (Books) Ltd., London. pp. 262-266. (ERL, GB Reprint #101d).

Data from surveillance programs of marine species to determine the kinetics and accumulation of DDT and its metabolites are reviewed. This paper was presented at a congress convened by the Food and Agriculture Organization (FAO) of the United Nations in Rome on December 9, 1970, to discuss global aspects of marine pollution.

289. Cooley, Nelson R. 1972. RESEARCH ACTIVITIES ON PESTICIDES AT THE ENVIRONMENTAL PROTECTION AGENCY LABORATORY, GULF BREEZE, FLORIDA. Proc. Pest Control Conference. Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL. 6:72-75. (ERL, GB Reprint #144).

This paper defines the research mission of the EPA Laboratory in Gulf Breeze, FL. Its investigations focus on three areas: ecological studies, physiological effects, and estuary monitoring. Data on the effects of pollutants on aquatic organisms obtained by the laboratory aid in decisions on the registration of pesticides for use in or near the aquatic environment.

290. Coppage, D.L., and T.W. Duke. 1972. EFFECTS OF PESTICIDES IN ESTUARIES ALONG THE GULF AND SOUTHEAST ATLANTIC COASTS. Proc. Second Gulf Coast Conference on Mosquito Suppression and Wildlife Management, Claude H. Schmidt, editor. National Mosquito Control - Fish and Wildlife Management Coordination Committee. pp. 24-31. (ERL, GB Reprint #138).

The presence of persistent pesticides in Gulf and Southeast Atlantic estuaries is well-documented. Examples of these are the chlorinated hydrocarbon pesticides DDT, dieldrin, endrin, aldrin, BHC-Lindane, heptachlor, toxaphene, and mirex. Pesticides are detected through monitoring programs in which organisms, sediment, and water are collected and analyzed. With these data and laboratory data on response of living organisms to pesticides, we can determine effects of environmental levels of the chemicals in an ecological and physiological context. This report reviews (i) some of the findings on residues of persistent pesticides in estuaries, (ii) some effects of these pesticides found in field and laboratory studies, and (iii) research on effects of malathion, a less persistent organophosphate pesticide used for mosquito control.

291. Rice, T.R., J.P. Baptist, F.A. Cross, and T.W. Duke. 1972. POTENTIAL HAZARDS FROM RADIOACTIVE POLLUTION OF THE ESTUARY. In: Marine Pollution and Sea Life, Mario Ruvio, editor. Fishing News (Books) Ltd., London. pp. 272-276.

Although generally small amounts of radioactive wastes are discharged into estuaries or reach them from river drainage areas, the volume of these discharges is expected to increase in the next 20 years. This paper examines this problem and summarizes results of experiments related to the effects of radioactive pollution on the aquatic ecosystem.

1971

292. Butler, P.A. 1971. INFLUENCE OF PESTICIDES ON MARINE ECOSYSTEMS. Proc. Royal Society of London, England. Series B, 177:321-329. (ERL, GB Reprint #129).

A bioassay program undertaken in 1958 has evaluated the toxicity of about 240 pesticides to estuarine fauna. Studies indicate that chronic levels of sublethal amounts of pesticides may have more damaging effects than transitory changes due to acutely toxic levels of pollution. The first five years of a program monitoring the incidence of synthetic pesticide residues in populations of North American shellfish has been completed. The run-off of surface waters from agricultural districts is indicated as the chief source of this type of pollution; municipal and industrial wastes, and the control of noxious insects, are regionally important sources. Observations of laboratory populations experimentally contaminated with DDT indicate, by extrapolation, that pesticide pollution is causing significant changes in mortality, growth rates, or resistance to disease in some marine populations.

293. Lowe, J.I., P.R. Parrish, A.J. Wilson, Jr., P.D. Wilson, and T.W. Duke. 1971. EFFECTS OF MIREX ON SELECTED ESTUARINE ORGANISMS. Trans. 36th N. Am. Wildl. Nat. Resour. Conf. pp. 171-186. (ERL, GB Reprint #124).

This paper summarizes the results of several laboratory experiments in which shrimp, blue crabs, fiddler crabs, and pinfish were exposed to mirex in food, in water, or in both. Information concerning the movement of mirex in simple food chains and the persistence of mirex in fire ant bait is presented also.

294. Lowe, Jack I., Paul D. Wilson, Alan J. Rick, and Alfred J. Wilson, Jr. 1971. CHRONIC EXPOSURE OF OYSTERS TO DDT, TOXAPHENE, AND PARATHION. Proc. Am. Shellfish. Assoc. 61:71-79. (ERL, GB Reprint #116).

Oysters, Crassostrea virginica, were reared from juveniles (27 mm mean height) to sexual maturity in flowing seawater chronically polluted with low levels (3.0 ppb, μg/l, or less) of DDT, toxaphene, and parathion. The study was performed in two phases for 2 years; the insecticides were administered as a mixture during the first phase and separately in the second phase of the experiment. The weights of oysters grown in a mixture (1.0 ppb each of DDT, toxaphene and parathion) of the three insecticides were significantly less ($\alpha = 0.05$) than control oysters after 9 months. This loss of weight was about 10% of the total body weight (including shell) of the oysters. Weights and heights of separate groups of oysters reared in seawater containing about 1.0 ppb of either DDT, toxaphene, or parathion were not statistically different from controls.

Oysters reared in the pesticide mixture had tissue changes associated with kidney, visceral ganglion, gills, digestive tubules, and tissues beneath the gut. A mycelial fungus was also present, indicating a breakdown in the oyster's natural defense against this parasite.

295. Panel on Monitoring Persistent Pesticides in the Marine Environment (Philip Butler, member). 1971. CHLORINATED HYDROCARBONS IN THE MARINE ENVIRONMENT. National Academy of Sciences, Washington, DC. 42 p.

This report surveys the literature related to problems arising from the dispersal of man's material to his surroundings, with emphasis on DDT and its degradation products. The panel attempts to point out lacunae in man's knowledge and suggest remedial actions. It is one of a series of studies published under auspices of the Ocean Affairs Board.

296. Parrish, Patrick R. 1971. A RESPIROMETER FOR DETERMINING THE EFFECT OF PESTICIDES AND RELATED POLLUTANTS ON OXYGEN CONSUMPTION OF ESTUARINE FISHES. Proc. 25th Ann. Conf. Southeast. Assoc. Game Fish Comm. pp. 602-606. (ERL, GB Reprint #135).

A continuous-flow respirometer was constructed to measure the effect of pesticides and related pollutants on oxygen consumption of estuarine fishes. The parts of the respirometer in contact with pollutants were constructed of glass and teflon for efficiency in cleaning. Filtered, irradiated seawater of constant temperature and salinity was gravity-fed through 10 experimental and 10 control respiration chambers in which individual fish were held. Flow rates through the chambers were controlled controlled by stopcocks and measured by flowmeters; dissolved oxygen was determined by the Winkler method before and after water passed through each chamber. Pollutants were metered into the experimental chambers by syringe pump.

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